



Application No.: 08/737,633

Docket No.: I0717.0003/0US0

Docket No.: I0717.0003

**IN THE UNITED STATES PATENT AND TRADEMARK OFFICE**

In re Patent Application of:

Fabrizio Samaritani, et al.

Application No.: 08/737,633

Group Art Unit: 1647

Filed: November 15, 1996

Examiner: R. Landsman

For: IFN BETA LIQUID FORMULATIONS

**DECLARATION**

I, Mark C. Manning, declare that

1. A copy of my Curriculum Vitae is attached hereto.
  
2. I have reviewed the entire file of the-above application in connection with this declaration.
  
3. I understand that what is being claimed is a liquid pharmaceutical composition which contains only from about 0.6 to 24 MIU/ml of interferon-beta, mannitol, an acetate buffer at a pH between 3.0 and 4.0 and, optionally, albumin; a process for making such a composition; and a hermetically sealed container in sterile conditions containing the liquid pharmaceutical composition. I further understand that the examiner has determined that when there is one MIU/ml interferon-beta, 54.6 mg/ml of mannitol, 0.5 mg/ml of albumin in a solution of 0.01 M acetate buffer at pH 3.5, the invention is both novel and unobvious.
  
4. I understand that claims in this application have been rejected as being obvious over a combination of Hanisch (U.S. Patent 5,643,566) in view of Hershenson (U.S. Patent

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5,004,605), possibly combined with Cymbalista (U.S. Patent 4,647,454). I disagree with the assertion that the claimed invention is obvious over these references for the following reasons.

5. The Hanisch patent relates to purifying and processing recombinant human interferon-beta or interleukin-2, in order to realize a composition in which in such recombinant protein is dissolved in a non-toxic, therapeutically compatible aqueous-based carrier at a pH ranging from 6.8-7.5. The procedures described are designed to avoid extreme alkaline conditions. In one procedure, the recombinant protein is desalinated at a pH of about 8.5-10 and the pH of the desalinated product adjusted to about 2-4, preferably 3-4, in order to precipitate the transfer component from the solution, which is then removed, and the pH is eventually raised to 6.8-7.5. Hanisch indicates that the low pH solution does not require a stabilizer at column 5, lines 16-19. As a result, the low pH solution can be maintained as a liquid or can be lyophilized and when lyophilized, a carbohydrate stabilizer such as dextrose or mannitol can be added (column 5, lines 20-23).

6. Hanisch makes claims (e.g., claims 2, 7, 17 and 19) for lyophilized formulations and not liquid formulations. It is well known that carbohydrates and polyols stabilize proteins in a liquid or lyophilized formulation by vastly different mechanisms. In a lyophilized preparation, the carbohydrates serve to replace the water removed by freeze-drying. In a liquid formulation, as claimed in Samaritani, the stabilization comes from acting as an excluded solute, thereby increasing the thermodynamic stability of the protein in solution. Hanisch does not teach such stabilization of a liquid formulation. This is a critical distinction.

7. Hanisch then teaches that the final stable pharmaceutical composition is the recombinant protein dissolved in a non-toxic, inert, therapeutically compatible aqueous-based

medium at a pH of 6.8-7.8 containing a stabilizer for the protein (column 6, lines 36-43). Claims 3-6 are based on this assertion. The patent indicates that the stabilizer in the pH 6.8-7.8 formulation can be human serum albumin (HSA), a mixture of HSA and dextrose, or human plasma protein fraction (PPF). The patent further indicates that the type of stabilizer and its concentration depends on the pH method, the formulation employed and on the protein and that for low pH formulations of interferon, PPF is preferred (column 9, lines 43-44). I note that the preference for PPF over HSA is reinforced by Example 3 in the patent, which shows that a low concentration of PPF provided a very clear interferon-beta material, while a high concentration of albumin was required to do the same. The relevant consideration here is that, since PPF is preferred over albumin, the suggestion is being made that PPF, rather than albumin, should be used in a stable liquid formulation.

8. To the extent that the Hanisch patent refers to mannitol and albumin, it does not indicate that the presence of both of these are needed, or even preferred, at any point in time.

9. I note that, in the most recent Office Action, it is asserted that even though Hanisch does not teach the use of a buffer in a pharmaceutical composition, those skilled in the art would immediately envision the use of a buffer in a preparation of a pharmaceutical composition and it would be obvious to use a buffer in order to maintain the pH of the solution, especially if the pharmaceutical composition was to be stored. I find nothing in Hanisch which suggests that that there is a problem in maintaining the pH of the solution without the presence of a buffer. Proteins are polyelectrolytes that can buffer solutions themselves. Moreover, at low concentrations, they may be unable to alter the pH of the solution significantly. In either case, a buffer is not necessarily needed, despite the assertions of the examiner. Moreover, given the large changes in pH during processing described in Hanisch, the choice of a single buffer would

be problematic and the teaching would have had to include specifications for buffer exchange, if the invention was to be practiced.

10. I understand that the Hershenson patent has been relied on to show the amount of interferon-beta. I understand that this patent has also been cited to show the use of a pH 2-4 buffer, and while it does so, incorporating the use of such a buffer in the Hanisch procedure is contraindicated of the reasons already stated.

11. The Hershenson patent indicates that the buffers described can be phosphoric acid, glycine and citric acid and more preferably, phosphate (column 9, lines 16-20). Acetate buffers are not disclosed.

12. Hershenson refers to a buffer-containing composition, which also contains what is referred to as a "stabilizer/solubilizer", which is either glycerol or certain polyethylene glycol polymers. First, there is no data to support the fact that these compounds are "solubilizers". In fact, it is well known that excluded solutes, like glycerol and PEG, increase the chemical potential of the native state, which would lower, not raise, the solubility. Certainly, there is no data in the literature to suggest that mannitol is a solubilizer of interferon. Second, Hershenson teaches that either PEG or glycerol is required for proper stabilization, with no mention of mannitol or albumin.

13. Even if one were to ignore the clear reasons not to employ a buffer in the Hanisch composition and employed a Hershenson buffer in the Hanisch composition, one would also employ either glycerol or the polyethylene glycol polymers as a stabilizer. The resulting composition would not be the composition claimed in the above-identified application, even ignoring the fact that there is no teaching of acetate buffer in either Hanisch or Hershenson.

14. I note that the Office Action states that Hershenson does not teach that glycerol or polyethylene glycol polymers are required. I disagree and believe that Hershenson does teach this. These stabilizers are included in every buffered composition described. Furthermore, the Hanisch patent does not contain a buffer in any of the final liquid formulations. Hershenson does not teach any lyophilized formulations. Therefore, even in combination, these two do not teach a low pH, liquid formulation containing buffer, mannitol and, possibly, albumin, as claimed in the current patent application. Taken together, they teach a buffered composition containing glycerol or a polyethylene glycol.

15. I understand the Cymbalista patent has been cited to show a connection between an acetate buffer and interferon-beta. The patent does teach a stable composition containing interferon-beta, conventional excipients, a buffer and PVP as a stabilizer. However, I see nothing in this reference that indicates that the PVP can be eliminated. In fact, all of the data in the patent indicates that PVP is not only essential but superior to other 'conventional' stabilizers. There is nothing in Cymbalist which shows that the acetate buffer would give any degree of stabilization in the absence of PVP. Moreover, the use of a buffer *per se* is contrary to Hanisch, as discussed earlier.

16. Given the prior art listed by the examiner, I see no evidence of obviousness of a stable, buffered liquid formulation of interferon-beta at low pH using mannitol and possibly albumin as stabilizers. Furthermore, I believe that the data in the application shows that the claimed combination gives surprising and unexpected results. Table 1 shows a formulation of interferon-beta in a citrate buffer at pH 3 losing 27% of its potency after day 1 and virtually all

activity after 30 days during accelerated stability tests at 50° C. The formulation lost 80% of its potency after one day during the 50° C accelerated stability tests in the citrate buffer at pH 4 and essentially lost 100% at pH 5 or 6. Table 3 shows essentially a total loss of activity on the seventh day of accelerated stability tests using an ascorbic buffer at pH 3 or 4 and the loss of almost 40% in a succinate buffer pH 3 or 4. Table 2 shows an acetate buffer at pH 5 and 6 gave losses of activity of 43-55% after one day of accelerated testing. However, using an acetate buffer at pH 3 and 4 resulted in a loss of activity after one day of accelerated testing of only 28% or less (see compositions IFN/3 or IFN/4 at 50°C), while after 30 days, there was a retention of 30% or more activity. All of these data indicate that the compositions claimed are novel and unanticipated.

17. The data shown in Table 5 should be taken into consideration. It shows that the formulation covered by the claims (ACE/MAN/3.5) does not decrease in its concentration of active ingredient (interferon-beta), even after storage at 25° C for 9 months! Nothing in the prior art teaches that the combination of the interferon-beta, mannitol and an acetate buffer at a pH between 3.0 and 4.0, and optionally albumin, will give such outstanding results. The outstanding results here are surprising and unexpected.

18. I note that the Office Action states that the major reason that the data has not been given weight is that the claims do not require a particular degree of stabilization other than effective "stabilizing". In fact, this is the case in nearly every formulation patent where a protein is the active ingredient. In all of my studies, a specific stabilization standard has never been required in a patent.

19. I declare that all statements made herein of my own knowledge are true and that all statements made on the information and belief are believed to be true and further that these

statements were made with the knowledge that willful false statements or the likes are made are punishable by fine or imprisonment, or both, under § 1001 of Title 18 of the U.S. Code, and that such willful false statements may jeopardize the validity of this application or any patent issued thereon.

Date: Sept. 26, 2003

By:   
Name:

## CURRICULUM VITAE

**Mark C. Manning, Ph.D.**

### **I. GENERAL INFORMATION**

<i>Home Address:</i>	4968 Valley Oak Drive Loveland, CO 80538	<i>Home Telephone:</i>	970-663-6006
<i>Office Address:</i>	School of Pharmacy, Room 227 Campus Box C238 University of Colorado Health Sciences Center Denver, CO 80262	<i>Office Telephone:</i>	303-315-6162
		<i>Office Fax:</i>	303-315-6281

### **II. EDUCATION**

<b>YEAR</b>	<b>INSTITUTION</b>	<b>DEGREE CONFERRED</b>
1978	Hope College	A.B., Chemistry
1979	Northwestern University	M.S., Chemistry
1983	Northwestern University	Ph.D., Inorganic Chemistry

### **III. PROFESSIONAL EXPERIENCES**

<b>YEAR</b>	<b>TITLE</b>	<b>INSTITUTION</b>
1978-1982	Graduate Student	Northwestern University (Dept. of Chemistry)
1982-1984	Postdoctoral Associate	Colorado State University (Dept. of Chemistry)
1984-1988	Postdoctoral Associate	Colorado State University (Dept. of Biochemistry)

### **IV. ACADEMIC APPOINTMENTS**

<b>YEAR</b>	<b>TITLE</b>	<b>INSTITUTION</b>
1988-1990	Assistant Professor of Pharmaceutical Chemistry	University of Kansas
1989-1990	Courtesy Assistant Professor of Biochemistry	University of Kansas
1990-1997	Assistant Professor of Pharmaceutics	University of Colorado Health Sciences Center
1997-present	Associate Professor of Pharmaceutics	University of Colorado Health Sciences Center
2001-present	Affiliate Faculty	Colorado State University
2002-present	Head, Pharmacology Laboratory Animal Cancer Center	Veterinary Teaching Hospital Colorado State University Veterinary Teaching Hospital

**V. CONSULTING ACTIVITIES**

**Scientific Advisory Boards:**

RxKinetix, Inc., Louisville, CO, Co-Founder, 1996. Co-Chair, Medical and Scientific Advisory Board, 1997-1999, 2001-present  
Imutec Corporation (now Lorus Pharmaceuticals), Scarborough, Ontario, Member, Medical and Scientific Advisory Board, 1995-1997  
HTD Biosystems, Hercules, CA, Co-Founder/Chief Technical Officer, 2001-present

**Consultant for:**

Alan Laufman, J.D., M.D., Dallas, TX, 1994  
Alza Corporation, Palo Alto, CA, 1994-1995; 1998-2000; 2002  
Amen, Thousand Oaks, CA, 2003  
Antigenics, Woburn, MA, 2002  
AntiVirals, Inc., Portland, OR, 1997  
Athena Neurosciences/Elan Pharmaceuticals, S. San Francisco, CA, 1998-2000  
Atrix Laboratories, Fort Collins, CO, 1992-1994; 1998-1999  
Baxter Healthcare, Round Lake, IL, 1998  
Baxter Hyland, Fremont, CA, 1998  
Bayer (formerly Miles) Biotechnology, Inc., Berkeley, CA, 1995-2001  
Bayer Pharmaceutical Division, Clayton, NC, 1997  
Bristol-Myers Squibb, New Brunswick, NJ, 1996-1997  
Cell Therapeutics, Seattle, WA, 2002  
Clifford Chance, New York, NY, 2000-2001  
Cytel Corporation, San Diego, CA, 1995  
Elan Pharmaceuticals, S. San Francisco, CA, 1999-2000  
G.D. Searle/Monsanto, Skokie, IL, 1998-1999  
ICOS, Bothell, WA, 2001-2002  
IntraBiotics, Mountain View, CA, 1999  
Millipore Corporation, Bedford, MA, 1997-1998  
Montgomery, Little and McGrew, Attorneys at Law, Englewood, CO, 1996  
NaPro Biotherapeutics, Boulder, CO, 1992-1995  
Novartis Pharmaceuticals, Summit, NJ, 2002  
Neurobiological Technologies, Inc., Richmond, CA, 1995-1997  
Oread Laboratories, Lawrence, KS, 1990  
Patzer Consulting, Portola Valley, CA, 2002  
R.W. Johnson Research Institute, Raritan, NJ, 1997-1998  
Roche Pharmaceuticals, Nutley, NJ, 2002  
Somatogen, Boulder, CO, 1994  
SP Pharmaceuticals, LLC, Albuquerque, NM, 2000  
Trimeris, Inc., Durham, NC, 1996

**VI. TEACHING ACTIVITY**

YR.	COURSE	SEMESTER	NO. OF CREDITS	STUDENTS	CONTACT HRS.
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*Colorado State University*

1987	CHEM 261	Inorganic Chemistry	3	25	48 lecture
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*University of Kansas*

1988	PHCH 631	Pharmaceutics Lab II	1	80	64 laboratory
1988	CHEM 959	Bioanalytical Chemistry	3	15	3 lecture
1989	PHCH 624	Pharmaceutics II	3	80	6 lecture
1989	BIOL 918	Physical Biochemistry	3	18	3 lecture
1989	PHCH 972	Mechanisms of Pharmaceutical Degradation	3	12	3 lecture
1989	PHCH 514	Pharmaceutics I	3	85	6 lecture
1989	PHCH 631	Pharmaceutics Lab II	1	85	52 laboratory

*University of Colorado*

1990	PHCH 870	Protein Structure and Stability	2	20	20 lecture
1990	PHCH 870	Protein Structure and Stability	2	20	20 lecture
1990	BIOL 922	Protein Biochemistry	3	10	4 lecture
1990	PHCH 624	Pharmaceutics II	3	85	9 lecture
1990	PHAR 3030	Pharmacy Calculations	1	100	7 lecture
1990	PHAR 3100/ 4100	Pharmaceutics I	3	200	14 lecture
1990	CHEM 6711	Advanced Topics in Biochemistry	4	25	3 lecture

**VI. TEACHING ACTIVITY (CONTINUED)**

YR.	COURSE		SEMESTER CREDITS	NO. OF STUDENTS	CONTACT HRS.
1991	PHSC 3110/ 4110	Pharmaceutics II	3	200	13 lecture
1991	PHSC 4110	Pharmaceutics Laboratory	1	80	76 laboratory
1991	PHAR 3030	Pharmacy Calculations	1	110	4 lecture
1991	PHAR 3100	Pharmaceutics I	3	110	13 lecture
1991	PHSC 3111	Pharmaceutics Laboratory	1	90	78 laboratory
1992	CHEM 5561	Physical Chemistry of Macromolecules	3	20	3 lecture
1992	PHSC 3110	Pharmaceutics II	3	110	14 lecture
1992	PHSC 3111	Pharmaceutics Laboratory	2	100	78 laboratory
1992	PHSC 3100	Pharmaceutics I	3	135	22 lecture
1993	PHSC 3110	Pharmaceutics II	3	130	22 lecture
1993	TXCL 7545	Principles of Drug Stability	1.3	2	10 lecture
1993	PHSC 3100	Pharmaceutics I	3	140	21 lecture
1993	PHSC 7656	Advanced Pharmaceutics	1.3	3	16 lecture
1993	PHSC 4810	Industrial Pharmacy	2	30	course coordinator
1994	PHSC 3110	Pharmaceutics II	3	140	45 lecture
1994	PHSC 3100	Pharmaceutics I	3	140	45 lecture
1994	PHSC 4810	Industrial Pharmacy	2	30	course coordinator
1994	PHSC 7480	Fundamentals of Drug Development and Drug Action	3.3	3	6 lecture

**VI. TEACHING ACTIVITY (CONTINUED)**

YR.	COURSE		SEMESTER CREDITS	NO. OF STUDENTS	CONTACT HRS.
1995	PHSC 3100	Pharmaceutics I	3	130	43 lecture
1995	PHSC 7300	Graduate Biochemistry	4	3	4 lecture
1995	MOLB 7800	Molecular Biology I	2.7	30	4 lecture
1995	PHSC 4810	Industrial Pharmacy	2	50	course coordinator
1995	PHSC 7370	Regulatory and Business Issues in Pharmaceutical Biotechnology	1.3	5	course coordinator
1996	PHSC 3110	Pharmaceutics II	3	130	1 lecture
1996	PHSC 3100	Pharmaceutics I	3	132	16 lecture/course coord.
1997	PHSC 3110	Pharmaceutics II	3	128	15 lecture
1997	PHSC 3100	Pharmaceutics I	3	105	24 lecture/course coord.
1997	PHSC 7300	Graduate Biochemistry	4	4	2 lecture
1997	PHSC 7350	Protein Chemistry	2.7	12	8 lecture/course coord.
1998	PHSC 3110	Pharmaceutics II	3	105	14 lecture
1998	PHSC 7370	Regulatory and Business Issues in Pharmaceutical Biotechnology	1.3	9	course coordinator
1998	PHSC 7354	Spectroscopic Analysis of Biomolecules	2.7	14	8 lecture/course coord.
1998	PHSC 3100	Pharmaceutics I	3	94	24 lecture/course coord.
1998	PHSC 7310	Graduate Pharmaceutics I	3	2	24 lecture/course coord.
1998/9	PHSC 7350	Protein Chemistry	2.7	5	8 lecture/course coord.
1999	PHSC 3110	Pharmaceutics II	3	90	14 lecture

**VI. TEACHING ACTIVITY (CONTINUED)**

YR.	COURSE		SEMESTER CREDITS	NO. OF STUDENTS	CONTACT HRS.
1999	PHRD 3600	Science Foundations I	3	90	22 lecture
1999	PHSC 7310	Graduate Pharmaceutics I	3	3	24 lecture/course coord.
1999	PHRD 3100	Pharmacy Seminar	2	90	2 lecture
1999	PHSC 7330	Issues in Drug Development	1.3	12	2 lecture
2000	PHSC 7345	Principles of Drug Delivery	1.3	8	4 lecture
2000	PHSC 7354	Spectroscopic Analysis of Biomolecules	2.7	13	6 lecture/course coord.
2000	PHRD 3600	Science Foundations I	3	90	12 lecture
2000	PHSC 7310	Graduate Pharmaceutics I	3	1	10 lecture/course coord.
2000	PHRD 3610	Science Foundations II	3	90	6 lecture
2000	PHRD 4700	Integrated Organ Systems III	3	90	2 lecture
2000	PHRD 3300	Experiential Practice I	1	90	6 laboratory
2000	PHSC 7330	Issues in Drug Development	1.3	13	4 lecture/course coord.
2000/1	PHSC 7350	Protein Chemistry I	2	20	17 lecture/course coord.
2001	PHRD 3600	Science Foundations I	3	115	12 lecture
2001	PHRD 5700	Integrated Organ Systems IX	3	85	2 lecture
2001	PHRD 4700	Integrated Organ Systems III	3	90	2 lecture
2001	PHRD 5200	Pharmacy Seminar	1	90	8 hours
2001	PRDO 5480	Pharmacy Seminar	1	60	8 hours
2001	PHRD 4100	Experiential Practice III	1	85	2 hours
2002	PHSC 7561	Introduction To Modern Biotechnology	1	15	1 hour

**VI. TEACHING ACTIVITY (CONTINUED)**

YR.	COURSE		SEMESTER CREDITS	NO. OF STUDENTS	CONTACT HRS.
2002	PHRD 5210	Pharmacy Seminar	1	90	8 hours
2002	PHSC 7370	Business Issues in Pharm. Biotechnology	1.3	12	6 lecture/course coord.
2002	PHRD 3600	Science Foundations I	3	120	13 lecture
2002	PHRD 3610	Science Foundations II	3	120	6 lecture
2002	PHRD 5700	Integrated Organ Systems IX 3		110	2 lecture
2002	PHSC 7330	Issues in Drug Development	1.3	12	2 lecture
2002/3	PHSC 7350	Protein Chemistry I	2	12	12 lecture

*Other*

Invited Lecturer, Center for Professional Advancement, Short Courses on "Stability of Protein Pharmaceuticals, Biologics, and Devices", New Brunswick, NJ, 1989-1993.

Invited Lecturer, Parenteral Drug Association Workshops on "Formulating Stable Biotechnology Products", New Brunswick, NJ, and San Diego, CA, 1995 and Lake Tahoe, CA 1996.

Invited Lecturer, Conference on Pharmaceutical Science and Technology Workshop on "Formulating Stable Protein Pharmaceutical Products", Chicago, IL, 1995 and 1996.

Invited Lecturer, American Association of Pharmaceutical Scientists, Short Course on "Issues in Formulation of Biopharmaceuticals", San Francisco, CA, 1998.

Invited Lecturer, American Association of Pharmaceutical Scientists, Short Course on "Lyophilization of Protein Pharmaceuticals", Indianapolis, IN, 2000.

Invited Lecturer, European Continuing Education College, Short Course on Formulation and Stabilization of Biomolecules", London, England, 2002.

Invited Lecturer, Formulation and Stabilization of Protein Pharmaceuticals, Breckenridge, CO, 2002

## **VII. ADVISING ACTIVITY**

### *A. Thesis Advisor for Ph.D. Students*

#### University of Kansas, Department of Pharmaceutical Chemistry

Ronda Gray (1988-1990, Ph.D. awarded, 1993)

Cecilia Oliyai (1988-1990, Ph.D. awarded, 1992) (joint with Dr. Ronald Borchardt)

Cynthia Stevenson (1988-1990, Ph.D. awarded, 1992) (joint with Dr. Ronald Borchardt)

#### University of Colorado, Department of Pharmaceutical Sciences

James Matsuura (1991-1996, Ph.D. awarded, 1996)

Robert Beauvais (1995-1999)

Jeffrey Meyer (1996-2001; Ph.D. awarded, 2001)

Charles Hughes (1996-2001; M.S. awarded, 2002)

Lixin Feng (1999-present) (joint with Dr. William Dernell, CSU)

Derrick Katayama (2000-present)

Mary Cromwell (2001-present)

ShuJun Bai (2002-present) (joint with Dr. John Carpenter)

Danny Chou (2002-present)

### *B. Member of Advisory Committee*

#### University of Kansas, Department of Pharmaceutical Chemistry

Jay Sisco (1988-1989, Ph.D. awarded, 1989)

Shohba Arkalgud (1989, M.S. awarded, 1989)

Kaushik Dave (1989-1990, Ph.D. awarded, 1990)

#### University of Kansas, Department of Medicinal Chemistry

Sam Chou (1990)

#### University of Colorado, Department of Pharmaceutical Sciences

Gary Walega (1990-1991)

Scott Myers (1991-1992)

Daniel Womer (1993-1994, Ph.D. awarded, 1994)

Julie Derby (1993-1994)

S. Dean Allison (1993-1998, Ph.D. awarded, 1998)

Brent Kendrick (1994-1997, Ph.D. awarded, 1997)

LaToya Jones (1997-2001; Ph.D. awarded, 2001)

Tunde Adesunloye (1999-2001)

Yong-Sung Kim (1999-2002; Ph.D. awarded, 2002) (chair of the committee)

S. Krishnan (1999-2002; Ph.D. awarded, 2002) (chair of the committee)

Huiyu Zhou (1999-present)

Andy Kosky (2000-present) (chair of the committee)

Nancy Stolpman (2000-2002; Ph.D. awarded, 2002) (chair of the committee)

Susan Babuka (2001-2002) (chair of the committee)

Lorinda Girouard (2002-present)

Ye Zhang (2002-present)

Mayank Patel (2002-present)

University of Colorado, Department of Chemical Engineering

Richard Falk (1995-1998, Ph.D. awarded, 1998)  
Serena Donnelly-Webb (1997-2001, Ph.D. awarded, 2001)  
Jon Webb (1997-2000; Ph.D. awarded, 2000)  
Jing Xu (1998-1999, M.S. awarded, 1999)  
Danielle Biggs (1999-present)  
Scott Lyman (1999-2000, M.S. awarded, 2000)  
Richard St. John (2000-2001, Ph.D. awarded, 2001)  
Roberto De Paz (2000-2001, Ph.D. awarded, 2001)  
Eva Chi (2000-present)  
Michael Stoner (2002-present)

*C. Advisor for Postdoctoral Students*

University of Colorado, Department of Pharmaceutical Sciences

Dr. Jen-Jen Lin (1998)  
Dr. Chuan Li (1999)  
Dr. Alexandra de Lille (2001-present) (joint with Dr. W. Dernell, CSU)

*D. Host for Visiting Scientists*

University of Colorado, Department of Pharmaceutical Sciences

Professor Lewis Stratton, Furman University (joint with John Carpenter)  
Dr. Francesco Meriani, University of Trieste (joint with William Dernell)

### **VIII. ADMINISTRATIVE ACTIVITY AND UNIVERSITY SERVICE**

#### *School of Pharmacy, University of Kansas*

Graduate Affairs Committee, 1988-1990

ad hoc Committee on Biotechnology in the Pharmacy Curriculum, 1989-1990

NMR Committee, 1989-1990

#### *School of Pharmacy, University of Colorado*

Student Ethics and Conduct Committee, 1990-1992, 1994-1999. Chair, 1997-1998

Curriculum Committee, 1990-1993. Served as Chair from 1992-1993

Executive Committee, Division of Pharmaceutical Sciences, 1991-1992

Computer and Information Sciences Committee, 1992-1993

Faculty Search Committees (8), 1991-2002. Served as Chair on two committees

Graduate Program in Pharmaceutical Sciences, Director, 1997-present

Computer and Information Technology Web Page Subcommittee, 1999

Scholastic Advancement and Appeals Committee, Chair, 2000-present

Appointment, Promotion, and Tenure Committee, 2000-2003

#### *University of Colorado Health Sciences Center*

Fitzsimons Research Park Advisory Committee, 1997-1999

Search Committee for Dean of the Graduate School, 1997-1998

Facilities and Administrative Waiver Committee, 2001-present

### **IX. SPECIAL ASSIGNMENTS**

Chair, ad hoc Committee on Team Teaching Evaluations, School of Pharmacy, University of Colorado, 1992

Member, ad hoc Leadership and Planning Task Force, Division of Pharmaceutical Sciences, School of Pharmacy, 1993

Member, ad hoc Graduate Core Course Planning Committee, Department of Pharmaceutical Sciences, School of Pharmacy, 1993-1994

Member, ad hoc Committee on Remediation/Academic Assistance Process, School of Pharmacy, 1999

Member, State of Colorado Health Care Task Force Subcommittee on Mandated Health Care Costs, 1999

Member, Colorado Alliance for Bioengineering Executive Council, 2000-2001

### **X. HONORS**

Visiting Summer Professor, Abbott Laboratories, 1989

Student (James Matsuura) won first place for best poster presentation at Graduate Research Association of Students in Pharmaceutics (GRASP) Meeting, Lincoln, NE, June, 1994

Invited Guest, Novo Nordisk Technology Conference on Protein Stability, Hvidøre, Denmark, August, 1997 (one of only five outside scientists invited)

1997 Research Achievement Award in Biotechnology from the American Association of Pharmaceutical Scientists

## **XI. PROFESSIONAL ACTIVITY AND PUBLIC SERVICE**

### ***A. Membership in Professional Organizations (past and present)***

American Association for the Advancement of Science (AAAS)  
American Association of Pharmaceutical Scientists (AAPS)  
American Chemical Society (ACS)  
American Phytopathological Society  
Controlled Release Society  
Biophysical Society  
Protein Society

### ***B. Grant Review Panels***

National Science Foundation, Biophysics Section, ad hoc Reviewer (1990, 1991, 1997, 1998)  
Parenteral Drug Association Foundation, Biotechnology Section (1992 and 1993)  
North Carolina Biotechnology Center Seed Grants (1994)  
Colorado Institute for Research in Biotechnology Seed Grants (1995-1999)  
Israel Science Foundation, ad hoc reviewer, 2001  
US Civilian Research and Development Foundation, ad hoc reviewer, 2002

### ***C. Journal Referee***

AAPS PharmSci  
American Chemical Society Symposium Series  
Archives of Biochemistry and Biophysics  
Biochemistry  
Biochimica et Biophysica Acta  
Biophysical Journal  
Bio/technology  
Biotechnology and Bioengineering  
Biotechnology Progress  
Biopolymers  
Chemico-Biological Interactions  
Comparative Biochemistry and Physiology  
Current Pharmaceutical Biotechnology  
Encyclopedia of Human Biology  
International Journal of Peptide and Protein Research  
International Journal of Pharmaceutics  
Journal of Agricultural and Food Chemistry  
Journal of the American Chemical Society  
Journal of Applied Polymer Science  
Journal of Drug Targeting  
Journal of Medicinal Chemistry  
Journal of Organic Chemistry  
Journal of Peptide Research  
Journal of Pharmaceutical and Biomedical Analysis  
Journal of Pharmaceutical Sciences

Life Sciences  
Molecular Biology Reports  
Nature Biotechnology  
Peptide Research  
Pharmaceutical Research  
Protein Engineering  
Protein Science  
Separation Science

*D. Editorial Boards*

Editor, Journal of Pharmaceutical and Biomedical Analysis, 1999-2000  
Member, Editorial Board, Journal of Pharmaceutical and Biomedical Analysis, 2000-2002.  
Member, Editorial Board, Current Pharmaceutical Biotechnology, 1999-present

*E. Other*

Member, Organizing Committee, Rocky Mountain Biomedical Development Forum, 1990-1993  
Member, Awards Committee, Parenteral Drug Association, 1992  
Chair, Abstract Screening Committee, BIOTEC Section, American Association of Pharmaceutical Scientists (AAPS), 1992  
Member, Advisory Board, Colorado Institute for Research in Biotechnology, 1993-present  
Co-Chair (with John Carpenter), Organizing Committee, Colorado Protein Stability Conference, 1994-present  
Co-host, Visiting Professor, Dr. Lewis Stratton, Dept. of Biology, Furman University, 1995-1996  
Organizer, Colorado Perspectives on Drug Delivery Conference, meeting held in July, 1996  
Member, Program Committee, 1995 Conference on Pharmaceutical Science and Technology in conjunction with the 1995 International Conference on Food Science and Technology and the 26th Annual Meeting of the Fine Particle Society, 1995  
Member, Graduate Faculty, University of Colorado at Boulder, 1995-present  
Member, Organizing Committee, Colorado Biopharmaceutical Drug Delivery Conference, 1996-1997  
Co-Director, University of Colorado Center for Pharmaceutical Biotechnology, 1997-present  
Member, Program Committee, BIOTEC Section, American Association of Pharmaceutical Scientists (AAPS), 1997-1998  
Member, Program Committee, PDD Section, American Association of Pharmaceutical Scientists (AAPS), 1997-1998  
Member, Biomolecular Structure Program, University of Colorado Health Sciences Center, 1997-1999  
Member, Organizing Committee, Colorado Macromolecular Drug Delivery Conference, 1998-present

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**Member, Steering Committee, American Association of Pharmaceutical Scientists (AAPS) Focus Group on Ocular Drug Delivery, 1999-2000**  
**Member, Genomics/Biotechnology Exploratory Group, University of Colorado Health Sciences Center, 1999**  
**Faculty Representative, Global Pharmaceutical Education Network, 2000-present**

## **XII. INVITED SPEAKING ENGAGEMENTS**

<u>Local and State</u>		
YEAR	ORGANIZATION	TITLE
1988	University of Kansas Lawrence, KS	Circular Dichroism and Protein Structure
1989	Society for Applied Spectroscopy Kansas City Section Kansas City, MO	Studying the Structure of Proteins Using Circular Dichroism Spectroscopy
1990	University of Colorado School of Pharmacy Boulder, CO	Stability of Protein Pharmaceuticals
1990	Colorado State University Department of Biochemistry Fort Collins, CO	Stability of Protein Pharmaceuticals
1990	University of Colorado Molecular Biophysics Supergroup Boulder, CO	Stability of Protein Pharmaceuticals
1991	University of Denver Department of Chemistry Denver, CO	Stability of Protein Pharmaceuticals
1991	Colorado State University Fort Collins, CO	Career Opportunities in the Pharmaceutical Sciences
1995	University of Colorado School of Pharmacy Boulder, CO	Novel Methods for Stabilizing and Delivering Therapeutic Agents
1995	Colorado RNA Center Minisymposium, University of Colorado, Boulder, CO	Circular Dichroism Studies of Poly- nucleotides
1997	University of Denver Department of Chemistry Denver, CO	Hydrophobic Ion Pairing: The Power of a Simple Idea

YEAR	ORGANIZATION	<u>National</u>	TITLE
1988	Upjohn Company Kalamazoo, MI		Determination of Protein Structure Using Circular Dichroism Spectroscopy
1988	Eli Lilly Indianapolis, IN		Determination of Protein Structure Using Circular Dichroism Spectroscopy
1989	22nd Higuchi Research Conference Lake of the Ozarks, MO		Analyzing Protein Structure by Circular Dichroism Spectroscopy
1998	Colorado School of Mines Golden, CO		Hydrophobic Ion Pairing: The Power of a Simple Idea
1999	University of Colorado Department of Biology Colorado Springs, CO		Multidisciplinary Training in Pharmaceutical Biotechnology
1999	State of Colorado Legislature Health Care Task Force Denver, CO		The Future of Pharmaceutical Care
1999	University of Colorado HSC Health Services Grand Rounds Denver, CO		Biotechnology, Pharmaceutical Development, and Intellectual Property Issues
2001	University of Colorado Department of Biology Colorado Springs, CO		Hydrophobic Ion Pairing: The Power of a Simple Idea
2001	Univ. of Colorado HSC School of Medicine Div. of Medical Oncology Denver, CO		Controlled Delivery of Paclitaxel using an Aqueous Poloxamer Gel: Pharmacokinetics and Efficacy Studies
2001	Colorado State University Dept. of Chemistry Fort Collins, CO		Hydrophobic Ion Pairing: The Power of a Simple Idea
2002	Fitzsimons Fourteeners Aurora, CO		Introduction to HTD BioSystems

1989	Abbott Laboratories N. Chicago, IL	Everything You Wanted to Know About Proteins
1990	Nasal and Pulmonary Delivery of Peptides and Proteins Princeton, NJ	Formulation Considerations: Solubility, Aggregation, and Chemical Degradation
1991	AAPS Eastern Regional Meeting East Brunswick, NJ	Spectroscopic Techniques for Determining Protein Structure
1991	Marion Merrill Dow Research Institute Kansas City, MO	Circular Dichroism Spectroscopy: Fundamentals, Techniques, and Applications
1993	Atrix Laboratories Fort Collins, CO	How Proteins Respond to Stress: Temperature and Solvent Effects
1993	AAPS Midwestern Regional Mtg. Chicago, IL	Spectroscopic Methods in the Analysis of Protein Stability
1993	Rocky Mountain Analytical Conference Denver, CO	Optical Spectroscopy in the Analysis of Protein Pharmaceuticals
1994	Somatogen, Inc. Boulder, CO	Current Research in Protein Structure and Stability at the Univ. of Colorado
1994	BioPharm National Meeting San Francisco, CA	Chemical and Physical Instabilities of Protein Pharmaceuticals
1994	Recovery of Biological Products VII San Diego, CA	Approaches for Increasing the Solution Stability of Proteins
1994	Biological Recognition at ONR Workshop Berkeley Springs, WV	Production of Soluble Enzymes in Organic Solvents Via Hydrophobic Ion Pairing
1994	Alza Corporation Palo Alto, CA	Potential for Hydrophobic Ion Pairing to Enhance Drug Delivery
1995	Cytel Corporation San Diego, CA	Structural Characterization of CY-1899 Using FT-Infrared Spectroscopy
1995	Bayer Biotechnology Berkeley, CA	Aggregation and Precipitation in Protein Biopharmaceuticals

1995	AAPS Midwestern Regional Mtg Chicago, IL	Structure and Stability of Proteins in Nonaqueous Environments
1995	NeXstar Pharmaceuticals Boulder, CO	Novel Drug Delivery Methods
1996	Neurobiological Technologies, Inc. Richmond, CA	Stability and Structure of Peptides in Solution
1996	Ribozyme Pharmaceuticals, Inc. Boulder, CO	Novel Approaches for the Delivery of Therapeutic Biomolecules
1996	Bayer Biotechnology Berkeley, CA	Enhanced Delivery of Pharmaceuticals Using Ion Pairing and Supercritical Fluid Technology
1996	Trimeris, Inc. Durham, NC	Development of Polypeptide Drug Products
1996	Hoffman- LaRoche Nutley, NJ	Use of Integrated Approaches for Assessing Stability during Preformulation Studies of Protein Pharmaceuticals
1996	Bristol-Myers Squibb New Brunswick, NJ	Approaches for Altering Protein Solubility
1997	Millipore Corporation Bedford, MA	Physical and Chemical Instability of Proteins
1997	Bayer Corporation Clayton, NC	Chemical and Physical Instabilities in Protein Pharmaceuticals
1997	Centeon, Inc. Kankakee, IL	Solution and Lyophilized Formulations of Protein Pharmaceuticals
1997	Neurobiological Technologies, Inc. Richmond, CA	A Case Study in Peptide Aggregation: Solution Behavior of Human CRF
1997	Colorado Biopharmaceutical Delivery Conference Breckenridge, CO	Combining Hydrophobic Ion Pairing and Precipitation with a Compressed Antisolvent Technologies: An Alternative Method for Preparing Controlled Release Microsphere Dosage Forms

1998	2nd Symposium on the Analysis of Well Characterized Biotechnology Pharmaceuticals San Francisco, CA	Approaches to the Analysis of Protein Aggregation in Pharmaceutical Formulations
1998	Stability and Interactions of Proteins in Delivery Systems Workshop, Controlled Release Soc. Las Vegas, NV	Stability of Proteins and Peptides in Poloxamer Gels
1998	University of Kansas Lawrence, KS	Hydrophobic Ion Pairing: The Power of a Simple Idea
1998	G.D. Searle Skokie, IL	Protein Aggregation
1998	AAPS National Meeting San Francisco, CA	Conformational Stability of Protein Pharmaceuticals
1999	Amgen Thousand Oaks, CA	New Methods for Controlled Delivery of Biopharmaceuticals
1999	Alza Corporation Palo Alto, CA	Altering Protein Solubility: Are Protein Suspensions Possible Dosage Forms?
1999	32nd Higuchi Research Conference Lake of the Ozarks, MO	New Models for Graduate Education in the Pharmaceutical Sciences
1999	Elan Pharmaceuticals S. San Francisco, CA	Conformational Stability of Proteins: Living in Glass Houses
1999	IntraBiotics Pharmaceuticals Mountain View, CA	Chemical and Physical Stability of Protein Pharmaceuticals
1999	Novel Approaches for Stabilization of Biomaterials DARPA Workshop Breckenridge, CO	Chemical Instability of Proteins
1999	AAPS National Meeting New Orleans, LA	Nonaqueous Formulations of Proteins Via Hydrophobic Ion Pairing
2000	DARPA Meeting on Cell Stasis Washington, DC	Beyond Cell Biology: A Pharmaceutical Approach to Biopreservation

2000	Genentech, Inc. S. San Francisco, CA	High-Throughput Formulation: Meeting the Coming Challenge
2000	IDEC Del Mar, CA	Decoding the Sequences of Antibody Light Chains: The Power of Multivariate Statistical Analysis
2000	Covance Raleigh, NC	High-Throughput Development: Meeting the Coming Challenge
2000	Alza Corp. Palo Alto, CA	High-Throughput Development: Meeting the Coming Challenge
2000	Chiron Corp. Emeryville, CA	High-Throughput Development: Meeting the Coming Challenge
2000	ZymoGenetics Seattle, WA	High-Throughput Development: Meeting the Coming Challenge
2000	Immunex Corp. Seattle, WA	High-Throughput Development: Meeting the Coming Challenge
2000	AAPS National Meeting Indianapolis, IN	Practical Aspects of Lyophilization of Protein Pharmaceuticals
2001	Bayer Corp. Clayton, NC	Garbage In, Garbage Out: The Importance of Biophysical Characterization in Drug Development
2001	IBC Conference on Formulation of Biopharmaceuticals San Diego, CA	Garbage In, Garbage Out: The Importance Physicochemical Characterization in Drug Development
2001	Antigenics, Inc. Woburn, MA	High Throughput Drug Development: Meeting the Coming Challenge
2001	NaPro Biotherapeutics Boulder, CO	Controlled Delivery of Paclitaxel using an Aqueous Poloxamer Gel: Pharmacokinetic and Efficacy Studies
2002	National Park Service Workshop on Remote Delivery of Vaccines Fort Collins, CO	Controlled Release of Biomolecules

2002           **6th Symposium on the Analysis of Well Characterized Biotechnology Pharmaceuticals**  
                  Washington, DC                   **High Throughput Development of Proteins Pharmaceuticals**

2002           **Hope College**  
                  Department of Chemistry  
                  Holland, MI                   **Hydrophobic Ion Pairing: The Power of a Simple Idea**

2002           **TSI**  
                  St. Paul, MN                   **High Throughput Development: Innovation in Bioanalytics**

2002           **Alza Corporation**  
                  Mountain View, CA                   **Stability and Solubility of Polypeptides**

2002           **Roche Pharmaceuticals**  
                  Nutley, NJ                   **Stability and Solubility of Polypeptides**

International

YEAR	ORGANIZATION	TITLE
1993	Fifth International Symposium on Circular Dichroism Pingree Park, Colorado, USA	Circular Dichroism of Peptides and Proteins in Nonaqueous Solvents
1994	Colorado Protein Stability Conf. Breckenridge, Colorado USA	Structure and Stability of Polypeptides Dissolved in Organic Solvents
1996	Imutec Corporation Scarborough, Ontario, CANADA	Use of NMR in the Analysis of Complex Biological Mixtures
1997	Novo Nordisk Technology Symposium on Protein Stability Hvidøre, DENMARK	Chemical Instability of Protein Pharmaceuticals: New Challenges
1997	Novo Nordisk Bagsværd, DENMARK	Chemical Instability of Protein Pharmaceuticals: New Challenges
1998	Colorado Protein Stability Conf. Breckenridge, Colorado USA	Effect of Additives on the Chemical Stability of Peptides and Proteins
2000	Colorado Protein Stability Conf. Breckenridge, Colorado USA	Decoding the Sequences of Antibody Light Chains: The Power of Multivariate Statistical Analysis

2000	Globalization of Pharmaceutics Education Network Meeting Uppsala, SWEDEN	The Use of Biophysical Methods to Assess the Stability of Peptides and Proteins
2001	Bradford Particle Design Bradford, ENGLAND	Hydrophobic Ion Pairing: The Power of a Simple Idea
2001	University of Bradford Bradford, ENGLAND	High Throughput Development: Meeting the Coming Challenge
2002	Novartis Pharmaceuticals Basel, SWITZERLAND	Importance of Biophysical Characterization in Formulation of Protein Pharmaceuticals
2002	Conference on Drug Delivery of Cytokines Torino, ITALY	Structure and Stability of a Novel Interferon Intended for Oral Delivery
2002	Novartis Pharmaceuticals Basel, SWITZERLAND	Analysis of Proteins: Critical Techniques
2002	Novartis Pharmaceuticals Basel, SWITZERLAND	Chemical Stability of Proteins
2002	Novartis Pharmaceuticals Basel, SWITZERLAND	Preformulation and Formulation Strategies
2002	Novartis Pharmaceuticals Basel, SWITZERLAND	Development Strategies for High Dose Formulations of Antibodies
2002	Novartis Pharmaceuticals Basel, SWITZERLAND	Accelerated Stress testing in the Development of Protein Pharmaceuticals
2002	Serono Roma, ITALY	Projection to Latent Structures (PLS): Application to Pharmaceutical Development

### **XIII. GRANT/RESEARCH ACTIVITY**

#### *Proposals Funded:*

##### **SmithKline and French, Circular Dichroism Spectrophotometer Instrumentation Grant**

Primary Investigator (P. I.), one-time grant, given in 12/88 for \$30,000.

This grant supported the renovation of a Cary 60 circular dichroism spectrophotometer which will provide an instrument capable of accurately measuring the far UV CD spectra of proteins and other biomolecules.

##### **J.R. and Inez W. Jay Research Fund, The University of Kansas, Development of Peptide Agents for the Control of Trauma-Induced Inflammation Within the Cerebrovasculature**

Co-P. I. with Dr. K. L. Audus and Dr. G. I. Georg, covering 7/89-6/90 for \$11,000 total costs.

This grant supported studies designed at synthesizing, characterizing, and testing vasopressin analogs which will be more stable and effective at controlling inflammation in the central nervous system.

##### **Kansas University General Research Fund, Conformation-Activity Relationships in Calcitonin Gene-Related Peptide (CGRP)**

P. I. of grant covering 7/88-6/89 for \$5,000 total costs.

This grant supported structural studies on CGRP. Once the conformation of CGRP in aqueous solution is determined, the importance of each structural element to activity and specificity will be evaluated.

##### **Kansas University General Research Fund, Renaturation of Recombinant Protein Pharmaceuticals from Inclusion Bodies**

P. I. of grant covering 7/89-6/90 for \$6,490 total costs.

This grant supported studies on the structural characterization of recombinant proteins found in inclusion bodies, as well as developing methods for increased efficiency in the solubilization and renaturation of these materials.

##### **American Heart Association - Kansas Chapter, Design of Antagonists of Endothelin, a Potent Vasoconstrictor**

P. I. of grant covering 6/89-5/90 for \$20,000 total costs.

This grant supported studies aimed at elucidating the three-dimensional structure of the peptide hormone, endothelin, and the subsequent design of antagonists as possible agents to control hypertension.

##### **National Institutes of Health, Pharmaceutical Aspects of Biotechnology Training**

Trainer of grant covering 12/89-11/94 for \$91,230 in direct costs (Year 1) (P. I. is Dr. Ronald T. Borchardt).

This training grant supported training of pre-doctoral students in various pharmaceutical aspects relating to biotechnology. Two of Dr. Manning's students were supported by this grant.

**Abbott Laboratories, Thrombolytics Venture, Stability of Urokinase and Other Protein Thrombolytics**

P. I. of grant covering 1/90-6/91 for \$19,071 total costs.

This grant supported studies on the thermal stability of thrombolytic proteins such as urokinase, prourokinase, and plasminogen. The role of solution conditions and additives in stabilization of these compounds will be evaluated.

**Colorado Institute for Research in Biotechnology, Spectroscopic Methods for Assessing the Stability of Recombinant Protein Pharmaceuticals**

P.I. of grant covering 7/90-6/91 for \$5,000 total costs.

This grant provided partial support for a circular dichroism (CD) spectrophotometer which would be used to analyze the stability of protein pharmaceutical conditions. These studies would provide insight into the proper formulation of these materials.

**University of Colorado, Committee on Academic Planning and Programs, Assessing the Stability of Protein Pharmaceuticals by Circular Dichroism Spectroscopy**

P.I. of grant covering 10/90-9/91 for \$5,345 costs.

This grant provided partial support for a circular dichroism (CD) spectrophotometer which would be used to analyze the stability of protein pharmaceutical conditions. These studies would provide insight into the proper formulation of these materials.

**Takeda Abbott Laboratories, Pharmaceutical Product Development, Stability of Leuprolide Formulations**

P.I. of grant covering 6/91-5/94 for \$45,000 total costs plus a supply budget of \$5,000 per year.

This grant supported studies on the mechanism of degradation, the development of stable formulations and sample analysis of dosage forms containing leuprolide, a LHRH agonist.

**American Cyanamid, Starter Grant in Formulation Research**

P.I. of grant covering 10/91-9/92 for \$5,000 total costs.

This grant supported work on the effect of excipients on the stability of protein and peptides.

**Schering-Plough Pharmaceuticals, Carboxy-Terminal Sequencing of Proteins**

Co-P.I. of grant covering 10/91-9/93 for \$20,000 total costs. (P.I. is E. Shefter)

This grant supported research on developing techniques to sequence the carboxy terminus of protein pharmaceuticals.

**Atrix Laboratories, In Vitro/In Vivo Correlations for Release of Growth Factors from the Atrigel Delivery System**

P.I. of grant covering 11/92-10/93 for \$48,000 total costs.

This grant supported the study of the relationship between release kinetics of growth factors from biodegradable polymers in vitro and in animals.

**University of Colorado Health Sciences Center, Office of the Chancellor,  
Computing Resources Proposal**

Co-P.I. (with Jim Ruth of the School of Pharmacy) of grant covering 12/92-10/93 for \$35,000 total costs.

This grant provided needed computational resources for the School of Pharmacy's academic and administrative programs.

**Colorado Institute for Research in Biotechnology, Enhanced Delivery of Peptides  
Via Hydrophobic Ion Pairing**

P.I. of grant covering 7/93-6/94 for \$15,000 total costs.

This grant supported work on evaluating the ability of hydrophobic ion pairing to improve the systemic delivery of peptide pharmaceuticals.

**Colorado Institute for Research in Biotechnology, Graduate Student Fellowship for  
James Matsuura**

P.I. of grant covering 7/93-6/94 for \$7,500 total costs.

This grant supported James Matsuura as a student training in biotechnology.

**Office of Naval Research, Molecular Biology Program, Homogeneous Enzyme  
Catalysis in Mixed Solvents**

P.I. of grant covering 10/94-9/95 for \$ 104,251 total costs.

This grant supports a project using hydrophobic ion pairing to affect the dissolution of active enzymes in nonaqueous solvents.

**Cytel Corporation, Preliminary Studies on CY-1899**

P.I. of grant covering 8/94-9/94 for \$800 total costs.

This grant was to make preliminary CD and IR measurements on CY-1899.

**Scios Nova, Inc., Preliminary Studies on ANF-like Peptides**

Co-P.I. (with John Carpenter of the School of Pharmacy) of grant covering 9/94-10/94 for \$1,250 total costs.

This grant was to make preliminary CD and IR measurements on an ANF derivative.

**Cytel Corporation, Structural Basis for the Activity of CY-1899**

Co-P.I. of grant (with John Carpenter of the School of Pharmacy) covering 11/94-5/95 for \$7,500 total costs and covering 6/95-12/95 for \$7,500 more in total costs.

This grant is to develop spectroscopic methods for assessing the structural basis of CY-1899 activity.

**Tektagen, Inc., Structural Studies of Extracellular Receptors**

P.I. of grant covering 5-95-8/95 for \$1,160 total costs.

This grant was to assess the solution structure extracellular receptors that might have therapeutic use.

**Neurobiological Technologies, Inc., Structure and Activity of Human CRF**  
Co-P.I. of grant covering 2/95-6/95 for approximately \$4,000 total costs (John Carpenter is the P.I.).  
This grant was to assess the solution structure and stability of CRF compounds that might have therapeutic use.

**NeXstar Pharmaceuticals, Research Fellowships in the Pharmaceutical Sciences**  
P.I. of grant covering 1/95-6/95 for \$10,400 total costs and \$4,750 in total costs for 7/95-9/95.  
These fellowships support undergraduate and graduate students in their research in pharmaceutical biotechnology.

**AutoImmune, Inc., Stability of Soluble Type II Collagen**  
P.I. of grant covering 1/95-12/95 for approximately \$4,500 total costs.  
This grant is to assess the thermal stability of soluble collagen for use in preventing disease.

**NaPro Biotherapeutics, Use of Circular Dichroism Spectroscopy as an Analytical Method for Bioactive Compounds**  
P.I. of grant covering 1/95-12/95 for approximately \$1,000 total costs.  
This grant supports investigations on the use of CD as an alternative to spectropolarimetry as a USP approved analytical method.

**National Institutes of Health,  $\alpha_1$ -Proteinase Inhibitor Deficiency and Emphysema**  
Collaborator (along with John Carpenter) on grant covering 7/95-6/00 for \$232,109 (Year 1) total costs (Prof. Jerry Brown in the School of Medicine is the P.I.)  
This grant supports studies on the structural aspects of  $\alpha_1$ -proteinase inhibitor and the impact on biological activity.

**Imutec Corporation, In Vivo Anticancer Activity Studies of Virulizin**  
P.I. of grant covering 3/96-2/97 for \$75,425 total costs.  
This grant would support ongoing efforts to better characterize Virulizin and determine its efficacy in treating lung cancer in mice (in collaboration with Prof. Al Malkinson).

**NaPro Biotherapeutics, In Vivo Anticancer Studies of Taxol**  
P.I. of grant covering 3/96-2/97 for \$10,000 total costs.  
This grant would support ongoing efforts to evaluate taxol for its efficacy in treating lung cancer in mice (in collaboration with Prof. Al Malkinson).

**Neurobiological Technologies, Inc., Behavior of Human CRF in Aqueous Solution**  
P.I. of grant covering 4/96-3/00 for \$28,287 (\$22,450) total (direct) costs  
This grant would support studies on the physical stability of human corticotropin releasing factor in aqueous solution.

**Ribozyme Pharmaceuticals, Pharmacokinetic Studies of Selected Ribozymes**

P.I. of grant covering 4/96-4/97 for approximately \$ 16,400 (\$13,106) total (direct) costs. This grant would support collaborative studies on the ability of microspheres and gels to affect clearance rates in two animal models.

**College of Veterinary Medicine and Biomedical Sciences, Colorado State University,**

**In Vitro and In Vivo Evaluation of Gentamicin Impregnated Polylactic Acid Beads**

Co-P.I. of grant covering 5/96-11/96 for \$14,500 total costs (P.I. is W. Dernell)

This grant would support studies examining the use of poly(lactide) beads for local delivery of aminoglycosides in the treatment of osteomyelitis.

**Colorado RNA Center, Controlled Release of RNA from Polymeric Microspheres**

Co-P.I. of grant (T. Randolph, P.I.) covering 7/96-6/97 for \$35,000 total costs.

This grant supports collaborative studies on the ability of microspheres and gels to affect clearance rates in two animal models.

**Bayer Biotechnology, Role of Human Serum Albumin in Aggregation of Formulated Protein Pharmaceuticals**

P.I. of grant covering 6/97-5/98 for \$50,000 total costs.

This grant will support studies on the role of HSA dimers as seeds for subsequent aggregation and precipitation of formulated proteins.

**Colorado State University College of Veterinary Medicine and Biomedical Sciences,**

**In Vivo Evaluation of Antibiotic Impregnated Beads in a Rat Osteomyelitis Model**

Collaborator on grant covering 7/97-6/98 for \$12,000 direct costs (P.I. is W. Dernell, CSU)

This grant will support studies on the ability of biodegradable beads containing antibiotics to control osteomyelitis, either prophylactically or therapeutically.

**RxKinetix, Inc., Controlled Release Drug Delivery Systems**

P.I. of grant covering 4/98-3/03 approved for \$250,000 total costs. Actual paid was \$25,000.

This grant will support studies on novel drug delivery systems for antibiotics and anticancer compounds.

**University of Colorado, Department of Pharmaceutical Sciences Seed Grant, Novel Cationic Detergents for Improved Delivery of DNA**

Co-P.I. (with three other colleagues) for grant covering 5/97-4/98 for \$10,000 total costs.

This grant supports studies on the development of new materials for preparation of cationic liposome delivery systems for DNA.

**Bayer Plasma Fractionation, Stability of Human Serum Albumin during Processing**

P.I. of grant covering 6/97-5/98 for \$46,380 total costs.

This grant will support studies on the stability of HSA during processing stresses.

**Colorado RNA Center, Controlled Release of RNA from Polymeric Microspheres**  
Co-P.I. of grant (T. Randolph, P.I.) covering 7/97-6/98 for \$25,000 total costs.  
This grant supports collaborative studies on the ability of injectable microsphere formulations to control release of ribozymes *in vivo*.

**Alza Research Institute, Support of the Colorado Biopharmaceutical Delivery Conference**  
Co-P.I. of grant (J. Carpenter, P.I.) covering the 1997 and 1999 meetings for \$50,000 total costs.  
This grant will support the drug delivery conference hosted by the University of Colorado Biopharmaceutical Delivery Conference.

**Colorado RNA Center, Controlled Release Microspheres for Delivery of Ribozyme Pharmaceuticals**  
Co-P.I. of grant covering 7/98-6/99 for \$25,000 total costs.

**Colorado Institute for Research in Biotechnology, Graduate Student Fellowship**  
Fellowship was given to Jeffrey Meyer for 1998-1999 (\$8,000 total award)

**Colorado Institute for Research in Biotechnology, A Controlled Release Drug Delivery System for the Treatment of Breast Cancer**  
P.I. of grant covering 7/98-6/99 for \$17,500 total costs.  
This grant supports research on the use of intracavitary drug delivery systems for immunotherapy in a breast cancer model.

**Baxter Hyland, Analysis of Monoclonal Antibodies**  
P.I. of grant covering 3/98-5/98 for \$ 8,400 in total costs.  
This contract supported studies on the solution behavior of therapeutic antibodies.

**National Institutes of Health, Training in Pharmacology of Antineoplastic Agents**  
Preceptor (P.I. is A. Kraft) for 12/98-11/03 for 778,261 (833,571) direct (total) costs  
This grant will support postdoctoral trainees in cancer research. Mentor of one trainee (Dr. A. De Lille) who is supported from 7/01-6/02.

**Elan Pharmaceuticals, Biophysical Characterization of Neuropeptides**  
P.I. of grant covering 11/98-6/01 for \$51,200 in total costs.  
This grant supports studies on the physical state of neuropeptide pharmaceuticals.

**National Institutes of Health, Aerosol-Based Nanoparticle Drug Delivery System for Tuberculosis**  
Collaborator (Lawrence Ng, P.I.) of grant covering 4/99-3/03 for \$920,000 total costs  
This grants supports work on the development of inhaled controlled release treatments for TB.

**Bayer Corporation, Stability of Interleukin-4 Analogs**

P.I. of grant covering 1/99-12/99 for \$42,000 total costs.

This grant supports work the stability of IL-4-like compounds in solution and the solid state.

**Coulter/Corixa Pharmaceuticals, Characterization of Protein Pharmaceuticals**

P.I. of grant covering 9/98-10/01 for \$17,000 total costs.

This grant supports work on the structural stability of protein pharmaceuticals.

**Genzyme Pharmaceuticals, Pilot Study on the Use of Hyaluronates as Delivery Systems for Proteins**

P.I. of grant covering 7/99-1/00 for \$3,000 total costs.

This grant supports work on the use of hyaluronates to stabilize proteins in gel-based drug delivery systems.

**American Foundation for Pharmaceutical Education, Graduate Fellowship to Jeffrey Meyer**

Fellowship was given to Jeffrey Meyer for 1999-2000 (\$8,000 total award). Renewed for 2000-2001 (\$6,000).

**G.D. Searle, Stabilization of Lyophilized Protein Pharmaceuticals**

P.I. of grant covering 12/99-11/00 for \$45,000 total costs.

This grant supports work on the stability of protein pharmaceuticals in the solid state.

**National Institutes of Health, Leadership Training in Pharmaceutical Biotechnology**

Co-P.I. (T. Randolph, PI) of training grant covering 7/01—6/06 for \$1,000,000 total costs.

This grant provides graduate student support for the Center's training programs.

**Colorado Institute for Research in Biotechnology, Controlled Release Drug Delivery System for Cancer Therapy**

Co-P.I. (W. Dernell, PI) of grant covering 7/90-6/00 for \$12,000 total costs.

This grant supports research on the use of intracavitary drug delivery systems for immunotherapy in a breast cancer model.

**Bayer Corporation, Development of High Throughput Formulation Strategies**

P.I. of grant supporting sabbatical work covering 12/99-11/00 for \$40,000.

This grant supported travel and research into new methods for improving the efficiency of the formulations process for biopharmaceuticals.

**McKee Foundation, Pharmacology Laboratory Equipment**

P.I. (along with W. Dernell) of gift for \$45,000 in total costs.

This gift will support establishing a pharmacology laboratory in the new Animal Cancer Center at Colorado State University.

**National Science Foundation, Shared Instrumentation Grant CTS 0079612**  
Collaborator (T. Randolph, P.I.) on grant covering 9/00-8/01 for \$192,000.  
This grant will provide a number instruments dedicated to solid state characterization of biomaterials.

**HTD Biosystems, Studies on New Interferon Products**  
P.I. of contract covering 3/01-4/02 for \$40,000 total costs.  
This contract supported studies on the stability and solubility of a novel interferon.

**GonexPets, Preformulation of Toxin-Gonadotropin Conjugate**  
P.I. of grant covering 8/01-7/02 for \$45,000 total costs.  
This grant covers studies on the stability and structure of a toxin-gonadotropin conjugate.

**Human Genome Sciences, Solution Behavior of a Novel Protein Hormone**  
P.I. of grant covering 1/02-12/02 for \$55,000 total costs.  
This grant supports studies on the structure and stability of growth factors in the solid state.

**ICOS, Kinetics of Protein Aggregation**  
P.I. of grant covering 5/02-4/03 for \$60,000 total costs.  
This grant supports studies on the appearance of protein aggregates during storage.

**HTD Biosystems, Studies on New Interferon Products**  
P.I. of contract covering 5/02-4/03 for \$15,000 total costs.  
This contract supported studies on the stability and solubility of a novel interferon.

**HTD Biosystems, Studies on Pegylated Proteins**  
P.I. of contract covering 4/02-3/03 for \$15,000 total costs.  
This contract supported studies on the stability and solubility of a novel interferon.

**Colorado State University, Head of Pharmacology Laboratory, ACC**  
P.I. of contract to provide 20% of my salary from 12/02-11/04.

Submitted:

**NIH, LC/MS/MS Purchase**

Co-investigator (R. Hodges, P.I.) of grant covering 10/03-9/04 for \$284,315 in total costs.

This grant will support the purchase of a micro-scale HPLC system and mass spectrometer.

**NIH, Affect of Preservatives on Protein Stability**

Co-P.I. (J. Carpenter, P.I.) of grant covering 8/03-7/08 for \$1,000,000 in direct costs.

This grant would support biophysical studies on the impact of preservatives on protein aggregation.

**NIH, Development of a Stable Botulism Vaccine**

Project Leader (I. Henderson, P.I.) of a U01 contract covering 7/03-6/07 for \$1.1 million in direct costs.

#### XIV. PUBLICATIONS

##### A. *Refereed Journals*

"Reduction of Metal Carbonyl Compounds Using Alkali Metal Carbides", Mark C. Manning and William C. Trogler, *Inorg. Chim. Acta* **1981**, 50, 247-250.

"X $\alpha$  Calculations and Spectroscopic Studies of Triruthenium and Triosmium Dodecacarbonyl", Bernard Delley, Mark C. Manning, Donald E. Ellis, Joseph Berkowitz, and William C. Trogler, *Inorg. Chem.* **1982**, 21, 2247-2253.

"Electronic Absorption Spectra of Tetra- $\mu$ -acetatodimolybdenum in Low Temperature Matrices" Mark C. Manning and William C. Trogler, *Inorg. Chem.* **1982**, 21, 2797-2800.

"The Electronic Structure of V(CO)<sub>6</sub>. Why It Is Black", Gary F. Holland, Mark C. Manning, Donald E. Ellis, and William C. Trogler, *J. Am. Chem. Soc.* **1983**, 105, 2308-2314.

"Electronic Absorption and Emission Spectra of Complexes Containing Dichromium, Dimolybdenum, and Ditungsten Quadruple Bonds", Mark C. Manning and William C. Trogler, *J. Am. Chem. Soc.* **1983**, 105, 5311-5320.

"Spectroscopic and Theoretical Studies on Binuclear Molybdenum (II) Carboxylates", Mark C. Manning, Gary F. Holland, Donald E. Ellis, and William C. Trogler, *J. Phys. Chem.* **1983**, 87, 3083-3088.

"Molecular Orbital Calculations on the Oligopeptides Netropsin, Distamycin, and Related Compounds", Mark C. Manning and Robert W. Woody, *Biopolymers* **1986**, 25, 2065-2082.

"Theoretical Determination of the Circular Dichroism of Proteins Containing Closely-Packed Antiparallel  $\beta$  Sheets", Mark C. Manning and Robert W. Woody, *Biopolymers* **1987**, 26, 1731-1752.

"Preparation and Characterization of Palladium(II)- and Platinum(II)-OTeF<sub>5</sub> Complexes", Mark R. Colsman, Mark C. Manning, Oren P. Anderson, and Steven H. Strauss, *Inorg. Chem.* **1987**, 26, 3958-3960.

"Synthesis and Reactions of Dinuclear Palladium Complexes Containing Methyls and Hydride on Adjacent Palladium Centers: Reductive Elimination and Carbonylation Reactions", S.J. Young, B. Kellenberger, Joseph H. Reibenspies, S.E. Himmel, M. Manning, O.P. Anderson, and J.K. Stille, *J. Am. Chem. Soc.* **1988**, 110, 5744-5753.

"Circular Dichroism Studies of Distorted  $\alpha$  Helices, Twisted  $\beta$  Sheets, and  $\beta$  Turns", Mark C. Manning, Mali Illangasekare, and Robert W. Woody, *Biophys. Chem.* **1988**, 31, 77-86.

"Comparison of the Secondary Structures of Human Class I and Class II MHC Antigens by IR and CD Spectroscopy", Joan C. Gorga, Aichun Dong, Mark C. Manning, Robert W. Woody, Winslow S. Caughey, and Jack L. Strominger, *Proc. Natl. Acad. Sci. USA* **1989**, 86, 2321-2325.

"Contribution of Aromatic Side Chains to the Circular Dichroism of Basic Bovine Pancreatic Trypsin Inhibitor (BPTI): A Theoretical Study", Mark C. Manning and Robert W. Woody, *Biochemistry* **1989**, 28, 8609-8613.

"Theoretical CD Calculations of Polypeptide Helices. Determination of the Important Electronic and Geometric Factors", Mark C. Manning and Robert W. Woody, *Biopolymers* **1991**, 31, 569-586.

Published as a faculty member:

"Conformation of the Alpha Form of Calcitonin Gene-Related Peptide (CGRP) in Aqueous Solution as Determined by Circular Dichroism Spectroscopy", Mark C. Manning, *Biochem. Biophys. Res. Commun.* **1989**, 160, 388-392.

"Underlying Assumptions in the Estimation of Secondary Structure Content in Proteins by Circular Dichroism Spectroscopy- A Critical Review", Mark C. Manning, *J. Pharm. Biomed. Anal.* **1989**, 7, 1103-1119.

"Protein Chemistry: A Graduate Course in Pharmaceutical Biotechnology at the University of Kansas", Mark C. Manning and James W. Mitchell, *Am. J. Pharm. Educ.* **1991**, 55, 52-55.

"Stability of the Thrombolytic Protein Fibrolase. Effect of Temperature and pH on Activity and Conformation", Denise Pretzer, Brenda S. Schulteis, Christopher D. Smith, David G. Vander Velde, James W. Mitchell, and Mark C. Manning, *Pharmaceutical Res.* **1991**, 8, 1103-1112.

"The Helix-Coil Transition in Heterogenous Peptides with Specific Side Chain Interactions", Paul M. Gans, Pingchiang C. Lyu, Mark C. Manning, Robert W. Woody, and Neville R. Kallenbach, *Biopolymers* **1991**, 31, 1605-1614.

"Effect of Zinc Binding on the Structure and Stability of Fibrolase, a Fibrinolytic Protein from Snake Venom", Denise Pretzer, Brenda S. Schulteis, Christopher D. Smith, David G. Vander Velde, James W. Mitchell, and Mark C. Manning, *Pharmaceutical Res.* **1992**, 9, 870-877.

"Structure and Stability of Insulin Dissolved in 1-Octanol", James Matsuura, Michael E. Powers, Mark C. Manning, and Eli Shefter, *J. Am. Chem. Soc.* **1993**, 115, 1261-1264.

"Conformation of Human Calcitonin Gene-Related Peptide(8-37) in Aqueous Solution as Determined by Circular Dichroism Spectroscopy", James Matsuura and Mark C. Manning, *J. Pharm. Biomed. Anal.* **1993**, 11, 89-93.

"Enhanced Solubility of Proteins and Peptides in Nonpolar Solvents Through Hydrophobic Ion Pairing", Michael E. Powers, James Matsuura, James Brassell, Mark C. Manning, and Eli Shefter, *Biopolymers* **1993**, 33, 927-932.

"Thermal Stability of Low Molecular Weight Urokinase During Heat Treatment. I. Effects of Protein Concentration, pH and Ionic Strength", William R. Porter, Harold Staack, Karol Brandt, and Mark C. Manning, *Thrombosis Research* **1993**, 71, 265-279.

"Delta-Sleep Inducing Peptide: Solution Conformational Studies of a Membrane-Permeable Peptide", Ronda A. Gray, David G. Vander Velde, Carl J. Burke, Mark C. Manning, Gautam Sanyal, C. Russell Middaugh, and Ronald T. Borchardt, *Biochemistry* **1994**, 33, 1323-1331.

"Solution Behavior of Leuprolide Acetate, a LHRH Agonist, as Determined by Circular Dichroism Spectroscopy", Michael E. Powers, Akwete Adjei, Mou-Ying Fu Lu, and Mark C. Manning, *Int. J. Pharm.* **1994**, 108, 49-56.

"Thermal Stability of Low Molecular Weight Urokinase during Heat Treatment. II. Effects of Polymeric Additives", Michael Vrkljan, Michael E. Powers, Thomas M. Foster, Jack Henkin, William R. Porter, John F. Carpenter, and Mark C. Manning, *Pharmaceutical Res.* **1994**, 11, 1004-1008.

"Selective Precipitation of Interleukin-4 Using Hydrophobic Ion Pairing: A Method for Improved Analysis of Proteins Formulated with Large Excesses of Human Serum Albumin", Jeffrey D. Meyer, James E. Matsuura, James A. Ruth, Eli Shefter, Suman T. Patel, James Bausch, Eugene McGonigle, and Mark C. Manning, *Pharmaceutical Res.* **1994**, 11, 1492-1495.

"Heat-Induced Gelation of Beta-Lactoglobulin: A Study of the Secondary and Tertiary Structure as Followed by Circular Dichroism Spectroscopy", James E. Matsuura and Mark C. Manning, *J. Agric. Food Chem.* **1994**, 42, 1650-1656.

"Solution Behavior of  $\alpha$ -Chymotrypsin Dissolved in Nonpolar Solvents Via Hydrophobic Ion Pairing", Jeffrey D. Meyer, James E. Matsuura, Brent S. Kendrick, Emily S. Evans, Gabriel J. Evans, and Mark C. Manning, *Biopolymers* **1995**, 35, 451-456.

"Sequence Analysis of Fibrolase, a Fibrinolytic Metalloproteinase from *Agkistrodon contortrix contortrix*", Mark C. Manning, *Toxicon* **1995**, 33, 1189-1200.

"Infrared and Circular Dichroism Spectroscopic Characterization of Structural Differences in  $\beta$ -Lactoglobulin Genetic Variants", Aichun Dong, James Matsuura, S. Dean Allison, Eric Chrisman, Mark C. Manning, and John F. Carpenter, *Biochemistry* **1996**, 35, 1450-1457.

"Quantitation of Area of Overlap between Second Derivative Amide I Infrared Spectra to Determine Structural Similarity of a Protein in Different States", Brent S. Kendrick, Aichun Dong, S. Dean Allison, Mark C. Manning, and John F. Carpenter, *J. Pharm. Sci.* **1996**, 85, 155-158.

"Generation of Soluble and Active Subtilisin in Organic Solvents Via Hydrophobic Ion Pairing", Jeffrey D. Meyer, Brent S. Kendrick, James E. Matsuura, James A. Ruth, Philip N. Bryan, and Mark C. Manning, *Int. J. Peptide Protein Res.* **1996**, 47, 177-181.

"Thermal Stability of Low Molecular Weight Urokinase during Heat Treatment. III. Effects of Salts, Sugars, and Additional Purification", Thomas M. Foster, Jonathon J. Dormish, Uday Narahari, Jeffrey D. Meyer, Michael Vrkljan, Jack Henkin, William R. Porter, John F. Carpenter, and Mark C. Manning, *Int. J. Pharm.* **1996**, 134, 193-202.

"Effect of Secondary Structure on the Activity of Enzymes Suspended in Nonaqueous Solvents", Aichun Dong, Jeffrey D. Meyer, Brent S. Kendrick, Mark C. Manning, and John F. Carpenter, *Arch. Biochem. Biophys.* **1996**, 334, 406-414.

"Dual Modes of Activation of Mitogen-Activated Protein Kinase Kinase 1 as Revealed by Kinetic Analysis and Mutagenesis", Sam Mansour, Julian M. Candia, James E. Matsuura, Mark C. Manning, and Natalie G. Ahn, *Biochemistry* **1996**, 35, 15529-15536.

"Controlled Release of Ionic Pharmaceuticals from Poly (L-lactide) Microspheres Produced by Precipitation with a Compressed Antisolvent", Richard F. Falk, Theodore W. Randolph, Jeffrey D. Meyer, R. Michael Kelly, and Mark C. Manning, *J. Controlled Rel.* **1997**, 44, 77-85.

"Investigation of the  $\alpha$ T244M Mutation in the Alpha Subunit of *Paracoccus dentrificans* Electron Transfer Flavoprotein", Kurt J. Griffin, Timothy M. Dwyer, Mark C. Manning, Jeffrey D. Meyer, John F. Carpenter, and Frank E. Frerman, *Biochemistry* **1997**, 36, 4194-4202.

"Secondary Structure of Human Cystathione  $\beta$ -Synthase in Aqueous Solution: Effect of Ligands and Proteolytic Truncation", Aichun Dong, Vladamir Kery, James Matsuura, Mark C. Manning, Jan P. Kraus, and John F. Carpenter, *Arch. Biochem. Biophys.* **1997**, 344, 125-132.

"Drug Delivery Matrix Containing Native Protein Precipitates Suspended in a Poloxamer 407 Gel", Lewis P. Stratton, Aichun Dong, Mark C. Manning, and John F. Carpenter, *J. Pharm. Sci.* **1997**, 86, 1006-1010.

"Structure-Activity Studies on Position 14 of Human- $\alpha$ -Calcitonin Gene-Related Peptide (h- $\alpha$ -CGRP)", Jianzhong Li, James E. Matsuura, Thomas E. Adrian, Mark C. Manning, and D. David Smith, *J. Med. Chem.* **1997**, 40, 3071-3076.

"Preferential Exclusion of Sucrose from Recombinant Human Interleukin-1 Receptor Antagonist: Role of Restricted Conformational Mobility and Compaction of Native State", Brent S. Kendrick, Byeong S. Chang, Tsutomu Arakawa, Ted Randolph, Mark C. Manning, and John F. Carpenter, *Proc. Natl. Acad. Sci. USA* **1997**, 94, 11917-11922.

"Spectroscopic Study of Secondary Structure and Thermal Denaturation of Recombinant Human Factor XIII in Aqueous Solution", Aichun Dong, Lotte Krielgaard, Brent S. Kendrick, James Matsuura, Mark C. Manning, and John F. Carpenter, *Arch. Biochem. Biophys.* **1997**, 347, 213-220.

"Use of Circular Dichroism Spectroscopy in Determining the Conformation of a Monoclonal Antibody Prior to its Incorporation in an Immunoliposome" Ka-yun Ng, Limin Zhao, Jeffrey D. Meyer, Lana Grauer-Kittman, and Mark C. Manning, *J. Pharm. Biomed. Anal.* **1997**, 16, 507-513.

"Hydrophobic Ion Pairing of Subtilisin BPN' Results in Structural Stabilization and Increased Activity in Isooctane", Brent S. Kendrick, Jeffrey D. Meyer, James E. Matsuura, John F. Carpenter, and Mark C. Manning, *Arch. Biochem. Biophys.* **1997**, 347, 113-118.

"The Phage Lambda Terminase Enzyme. 1. Reconstitution of the Holoenzyme from the Individual Subunits Enhances the Thermal Stability of the Small Subunit", Jeffrey D. Meyer, A. Hanagan, Mark C. Manning, and Carlos Enrique Catalano, *Int. J. Biol. Macromol.* **1998**, 23, 27-36.

"The Phage Lambda Terminase Enzyme. 2. Refolding of the gpNu1 Subunit from the Detergent-Denatured and Guanidinium Hydrochloride-Denatured State Yields Different Oligomerization States and Altered Protein Stabilities", Jeffrey D. Meyer, Adrienne Hanagan, Mark C. Manning, and Carlos Enrique Catalano, *Int. J. Biol. Macromol.* **1998**, 23, 37-48.

"Alveolar Macrophage Cell Line is Not Activated by Exposure to Polymeric Microspheres", Ka-yun Ng, Kathleen A. Stringer, Zoe Cohen, Robert Serravo, Bin Tian, Jeffrey D. Meyer, Richard Falk, Theodore W. Randolph, Mark C. Manning, and David C. Thompson, *Int. J. Pharm.* **1998**, 170, 41-50.

"Preparation and In Vitro Characterization of Gentamycin-Impregnated Biodegradable Beads Suitable for Treatment of Osteomyelitis", Jeffrey D. Meyer, Richard F. Falk, R. Michael Kelly, Jesse E. Shively, Steven J. Withrow, William S. Dernell, Theodore W. Randolph, and Mark C. Manning, *J. Pharm. Sci.* **1998**, 87, 1149-1154.

"Aggregation of Recombinant Human Interferon-gamma: Kinetics and Structural Transitions", Brent S. Kendrick, Jeffrey L. Cleland, Xanthe Lam, Tue Nguyen, Theodore W. Randolph, Mark C. Manning, and John F. Carpenter, *J. Pharm. Sci.* **1998**, 87, 1069-1076.

"Intermolecular  $\beta$ -Sheet Results from Trifluoroethanol-Induced Non-Native  $\alpha$ -Helical Structure in  $\beta$ -Sheet Predominant Proteins: Infrared and Circular Dichroism Spectroscopic Study", Aichun Dong, James E. Matsuura, Mark C. Manning, and John F. Carpenter, *Arch. Biochem. Biophys.* **1998**, 355, 275-281.

"Effects of Drying Methods and Additives on Structure and Function of Actin: Mechanisms of Dehydration-Induced Damage and Its Inhibition", S. Dean Allison, Theodore W. Randolph, Mark C. Manning, Kim Middleton, Ashley Davis, and John F. Carpenter, *Arch. Biochem. Biophys.* **1998**, 358, 171-181.

"Secondary Structure of Antifreeze Proteins from Overwintering Larvae of the Beetle *Dendroides canadensis*", Ning Li, Brent S. Kendrick, Mark C. Manning, John F. Carpenter, and John G. Duman, *Arch Biochem. Biophys.* **1998**, 360, 25-32.

"Effect of Tween 20 on Freeze-Thawing and Agitation-Induced Aggregation of Recombinant Human Factor XIII", Lotte Krielgaard, LaToya S. Jones, Theodore W. Randolph, Sven Frokjaer, James M. Flink, Mark C. Manning, and John F. Carpenter, *J. Pharm. Sci.* **1998**, 87, 1597-1603.

"Tween Protects Recombinant Human Growth Hormone against Agitation-Induced Damage via Hydrophobic Interactions", Narendra B. Bam, Jeffrey L. Cleland, Mark C. Manning, John F. Carpenter, Robert F. Kelley, and Theodore W. Randolph, *J. Pharm. Sci.* **1998**, 87, 1554-1559.

"Cloning, Expression and Characterization of a DNA Binding Domain of gpNu1, a Phage Lambda DNA Packaging Protein", Qin Yang, Tonny de Beer, Liping Woods, Jeffrey D. Meyer, Mark C. Manning, Michael Overduin, and Carlos Enrique Catalano, *Biochemistry* **1999**, 38, 465-477.

"Binding of Pyridoxal 5'-Phosphate to the Heme Protein Cystathione  $\beta$ -Synthase", Vladamir Kery, Loelle Poneleit, Jeffrey D. Meyer, Mark C. Manning, and Jan P. Kraus, *Biochemistry* **1999**, 38, 2716-2724.

"In Vitro Release Kinetics of Gentamycin Sulfate from a Hyaluronate Gel Delivery System for the Treatment of Peripheral Vestibular Disease", R. Michael Kelly, Jeffrey D. Meyer, James E. Matsuura, Eli Shefter, Michael J. Hart, Daniel C. Malone, and Mark C. Manning, *Drug Dev. Ind. Pharm.* **1999**, 25, 15-20.

"Tyrosine, Phenylalanine, and Disulfide Contributions to the Circular Dichroism of Proteins: CD Spectra of Wild Type and Mutant Bovine Pancreatic Trypsin Inhibitor", Narasimha Sreerama, Mark C. Manning, Micheal E. Powers, Jian-Xin Zhang, David P. Goldenberg, and Robert W. Woody, *Biochemistry* **1999**, 38, 10814-10822.

"Domain Structure of gpNu1, a Phage Lambda DNA Packaging Protein: Identification of Self-Association and gpA-Interactive Domains", Qin Yang, Nancy Berton, Mark C. Manning, and Carlos E. Catalano, *Biochemistry* **1999**, 38, 14238-14247.

"Optimizing Storage Stability of Lyophilized Actin with Dextran/Disaccharide Mixtures", S.D. Allison, A. Williams, K. Middleton, T.W. Randolph, M.C. Manning and J.F. Carpenter, *J. Pharm. Sci.* **2000**, 89, 199-214.

"Long Chain Arginine Esters: A New Class of Biocompatible Cationic Detergents", David J. Claffey, Jeffrey D. Meyer, Robert Beauvais, Tessa Brandt, Eli Shefter, David J. Kroll, James A. Ruth, and Mark C. Manning, *Biochem. Cell Biol.* **2000**, 78, 59-65.

"Thermodynamic Modulation of Light Chain Amyloid Fibril Formation", Yong-sung Kim, Jonathan S. Wall, Jeffrey Meyer, Charles Murphy, Theodore W. Randolph, Mark C. Manning, and John F. Carpenter, *J. Biol. Chem.* **2000**, 275, 1570-1573.

"Intracavitory Slow Release Paclitaxel Polymer in a Rodent Model of Mammary Carcinoma", V.S. Bregazzi, W.S. Dernell, D.J. Huber, R. Schochet, M. Lafferty, G.K. Oglivie, S.J. Withrow, B.E. Powers, and M. Manning, *J. Bioactive Compatible Polym.* **2000**, 15, 85-88.

"Stability of Human Serum Albumin during Bioprocessing. Denaturation and Aggregation during Processing of Albumin Paste", Jen-Jen Lin, Jeffrey D. Meyer, John F. Carpenter, and Mark C. Manning, *Pharmaceutical Res.* **2000**, 17, 391-386.

"Effect of Zinc-Binding and Precipitation on Structures of Recombinant Human Growth Hormone and Nerve Growth Factor", Tzung-Horng Yang, Jeffrey L. Cleland, Jeffrey D. Meyer, LaToya S. Jones, Theodore W. Randolph, Mark C. Manning, and John F. Carpenter, *J. Pharm. Sci.* **2000**, 89, 1480-1485.

"Comparative FT-IR and CD Spectroscopic Analysis of  $\alpha_1$ -Proteinase Inhibitor and Ovalbumin in Aqueous Solution", Aichun Dong, Jeffrey D. Meyer, Mark C. Manning, Jerry L. Brown, and John F. Carpenter, *Arch. Biochem. Biophys.* **2000**, 383, 148-155.

"Counteracting Effects of Renal Solutes in Amyloid Fibril Formation by Immunoglobulin Light Chains", Yong-sung Kim, Stephen P. Cape, Eva Chi, Rosemarie Raffen, Priscilla Wilkins-Stevens, Fred J. Stevens, Mark C. Manning, Theodore W. Randolph, Alan Solomon, and John F. Carpenter, *J. Biol. Chem.* **2001**, 276, 1626-1633.

"In Vivo Evaluation of Gentamicin-Impregnated Polylactic Acid Beads Implanted in Sheep", W.S. Dernell, S.J. Withrow, M.C. Manning, C.A. Kuntz, R. Dewell, F.B. Garry, B.E. Powers, J.E. Shively, R.F. Falk, and T.W. Randolph, *J. Bioactive Compatible Polym* **2001**, 16, 119-135.

"In Vivo Evaluation of Antibiotic-Impregnated Beads in a Rat Osteomyelitis Model", W.S. Dernell, C. Gentry-Weeks, M. C. Manning, B.E. Powers, M. Lafferty, C.A. Kuntz, J.E. Shively, R.F. Falk, J.D. Meyer, T.W. Randolph, and S.J. Withrow, *J. Bioactive Compatible Polym* **2001**, 16, 235-252.

"The Effect of Including Tween 20 and/or Sucrose in the Lyophilization and Reconstitution Medium of a Lyophilized Antibody", LaToya S. Jones, Theodore W. Randolph, Ulrich Kohnert, Apollon Papadimitriou, G. Winter, Marie-Luise Hagmann, Mark C. Manning, and John F. Carpenter, *J. Pharm. Sci.* **2001**, 90, 1466-1477.

"Controlling Deamidation Rates in a Model Peptide: Effects of Temperature, Peptide Concentration, and Additives", Lewis P. Stratton, R. Michael Kelly, Jared Rowe, Jesse E. Shively, D. David Smith, John F. Carpenter, and Mark C. Manning, *J. Pharm. Sci.* **2001**, 90, 2141-2148.

"Evaluation of Cisplatin in Combination with a Biological Response Modifier in a Murine Mammary Carcinoma Model", Emanuela, Morello, William S. Dernell, Charles A. Kuntz, Mary Lafferty, Ann Nelson, John H. Brekke, Craig H. Mallinckrodt, Stephen J. Withrow, and Mark C. Manning, *Cancer Investigations* **2002**, 20, 480-489.

"Ion Pairing of Isoniazid Using a Prodrug Approach", Huiyu Zhou, Corinne S. Lengsfeld, David J. Claffey, James A. Ruth, Brooks A. Hybertson, Theodore W. Randolph, Ka-yun Ng, and Mark C. Manning, *J. Pharm. Sci.* **2002**, 91, 1502-1511.

"Aggregation of Granulocyte Colony Stimulating Factor under Physiological Conditions: Characterization and Thermodynamic Inhibition", Sampathkumar Krishnan, Eva Y. Chi, Jonathan N. Webb, Byeong S. Chang, Daxian Shan, Merrill Goldenberg, Mark C. Manning, Theodore W. Randolph, and John F. Carpenter, *Biochemistry* **2002**, 41, 6422-6431.

"Dissolution and Partitioning Behavior of Hydrophobic Ion Paired Complexes", Douglas Pitera, Corinne S. Lengsfeld, Mark C. Manning, and Theodore W. Randolph, *Pharm. Res.* **2002**, 19, 1572-1576.

"Characterization of the Solution Conformations of Leuprolide Acetate", Jeffrey D. Meyer, Mark C. Manning, and David G. Vander Velde, *J. Peptide Res.* **2002**, 60, 159-168.

“Lipid Unsaturation Determines the Interaction of AFP Type I with Model Membranes during Thermotropic Phase Transitions”, Melanie M. Tomczak, László Vigh, Jeffrey D. Meyer, Mark C. Manning, Dirk. K. Hincha, and John H. Crowe, *Cryobiology* 2002, **45**, 135-142.

“Slowing Oxidation Rates in the Peptide Hormone, hCRF, via Manipulation of Quaternary Structure”, Jeffrey D. Meyer, Bert Ho, Margaret Moreland, Robert Cunico, and Mark C. Manning, *Pharm. Res.* 2002, submitted for publication.

“Effects of KBr Disk Formation on the Infrared Spectra of Model Proteins”, Jeffrey D. Meyer, Mark C. Manning, and John F. Carpenter, *Anal. Biochem.* 2002, manuscript in preparation.

“Infrared Spectroscopic Studies of Protein Formulations Containing Glycine”, Jeffrey D. Meyer, Rajiv Nayar, John F. Carpenter, and Mark C. Manning, *J. Pharm. Sci.* 2002, submitted for publication.

“Retrospective Statistical Analysis of Lyophilized Protein Formulations of Progenipoitin Using PLS. Determination of the Critical Parameters for Long-Term Storage Stability”, Derrick S. Katayama, Carol. F. Kirchhoff, Carrie M. Elliott, Robert Johnson, Jeffry Borgmeyer, Barrett R. Thiele, David L. Zeng, Hong Qi, John D. Ludwig, and Mark C. Manning, *Pharm. Res.* 2002, submitted for publication.

“Instability of Lipid-DNA Interactions during Lipoplex Formation”, Ye Zhang, William Garzon-Rodriguez, Mark C. Manning, and Thomas J. Anchordoquy, *Biochim. Biophys. Acta.* 2002, submitted for publication.

“Increased Efficacy of Hydrophobic Ion-Paired Tetracycline as Determined by Growth Rates of *Escherichia coli*”, Danielle L. Biggs, Corinne S. Lengsfeld, Mark C. Manning, and Theodore W. Randolph, *J. Pharm. Sci.* 2002, manuscript in preparation.

“*In Vitro* Macrophage Cellular Response to Poly(L-Lactide) Microspheres of Varying Crystallinity”, Danielle L. Biggs, Corinne S. Lengsfeld, Ka-Yun Ng, Brooks M. Hybertson, Mark C. Manning, and Theodore W. Randolph, *J. Pharm. Sci.* 2002, manuscript in preparation.

“Effects of Sucrose on Conformational Equilibria and Fluctuations within Native State Ensemble of Proteins”, Yong-sung Kim, LaToya S. Jones, Aichun Dong, Brent S. Kendrick, Byeong S. Chang, Mark C. Manning, Theodore W. Randolph, and Mark C. Manning, *Biochemistry* 2002, manuscript in preparation.

“The Role of Tween 20 in the Prevention of Freeze-Thaw-Induced Aggregation of a Four Helix Bundle Protein, Recombinant Human Granulocyte-Colony Stimulating Factor”, LaToya S. Jones, Theodore W. Randolph, Byeong S. Chang, Mark C. Manning, and John F. Carpenter, *J. Pharm. Sci.* 2002, manuscript in preparation.

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*B. Nonrefereed Articles*

"Excited State Electronic Structure of Molybdenum (II) Carboxylates, Tetrakis (6-Methyl-2-oxopyridinato)dichromium, -dimolybdenum, and -ditungsten", Mark C. Manning, Ph.D. Thesis, Northwestern University, 1983.

Published as a faculty member:

"The Use of Computer Aided Modeling to Understand Peptide Transport", R.A. Gray, D.G. Vander Velde, R.T. Borchardt, C.J. Burke, C.R. Middaugh, and M.C. Manning, *Chemical Design Automation News* 1992, 7, 1, 36-39, 41.

"Enhanced Potency of Ion-Paired Complexes of Cisplatin", Lixin Feng, William S. Dernell, and Mark C. Manning, *Veterinary Cancer Society Newsletter*, Fall 2000, pp. 4-5.

"Protein Storage and Stabilization", John F. Carpenter, Mark C. Manning, and Theodore W. Randolph, *Current Protocols in Protein Science*, in press, 2002.

*C. Review Articles (Refereed)*

"Electronic Structure of Transition Metal Cluster Complexes", Mark C. Manning and William C. Trogler, *Coord. Chem. Rev.* **1981**, 38, 89-138.

Published as a faculty member :

"Stability of Protein Pharmaceuticals", Mark C. Manning, Kamlesh Patel, and Ronald T. Borchardt, *Pharmaceutical Res.* **1989**, 6, 903-918.

"Protein Structure and Stability Assessment by Circular Dichroism Spectroscopy", Mark C. Manning, in Biocatalyst Design for Stability and Specificity, Michael E. Himmel and George Georgiou, Eds., *ACS Symposium Series 1992*, 516, 33-52.

"Approaches for Increasing the Solution Stability of Proteins", Mark C. Manning, James E. Matsuura, Brent S. Kendrick, Jeffrey D. Meyer, Jonathon J. Dormish, Michael Vrkljan, James R. Ruth, John F. Carpenter, and Eli Shefter, *Biotechnol. Bioeng.* **1995**, 48, 506-512.

"Hydrophobic Ion Pairing: Altering the Solubility of Biomolecules", Jeffrey D. Meyer and Mark C. Manning, *Pharmaceutical Res.* **1998**, 15, 188-193.

"Inhibition of Stress-Induced Aggregation in Protein Therapeutics", John F. Carpenter, Brent S. Kendrick, Byeong S. Chang, Mark C. Manning, and Theodore W. Randolph, in Methods in Enzymology, R. Wetzel, ed., Academic Press **1999**, 309, 236-255.

"High Throughput Drug Development: Meeting the Coming Challenges", Rajiv Nayar and Mark C. Manning, *BioPharm* **Feb. 2002**, 25-32.

"Encapsulating DNA within Biodegradable Polymeric Microspheres", Corinne S. Lengsfeld, Mark C. Manning, and Theodore W. Randolph, *Curr. Pharm. Biotechnol.* **2002**, 3, 227-235.

"The Stability Factor: Importance in Formulation Development", Rajesh Krishnamurthy and Mark C. Manning, *Curr. Pharm. Biotechnol.* **2002**, in press.

"The Use of Design of Experiment Software in Formulation Research", Rajiv Nayar and Mark C. Manning, *J. Pharm. Sci.* **2002**, manuscript in preparation.

"High Throughput Formulation of Protein Pharmaceuticals in the Post-Genomic Era", ShuJun Bai, Derrick S. Katayama, Danny K.C. Chou, Rajiv Nayar, Thomas J. Anchordoquy, and Mark C. Manning, *American Genomic/Proteomic Technology 2002*, manuscript in preparation.

*D. Book Chapters*

Published as a faculty member:

"Pharmaceutical Biotechnology. Protein Stability and Its Enhancement- An Overview", Tim J. Ahern and Mark C. Manning, in Pharmaceutical Biotechnology, Volume 2, Tim J. Ahern and Mark C. Manning, Eds., Plenum Press, New York, **1992**, pp. ix-xvii.

"Fibrolase, a Fibrinolytic Protein from Snake Venom", Denise Pretzer, Brenda Schulteis, Chris Smith, David G. Vander Velde, James W. Mitchell, and Mark C. Manning, in Pharmaceutical Biotechnology, Volume 5, Y. J. Wang and R. Pearlman, Eds., Plenum Press, **1993**, 287-314.

"Circular Dichroism in the Analysis of Protein Structure", John F. Towell, III and Mark C. Manning, in Analytical Applications of Circular Dichroism, N. Purdie and H.G. Brittain, Eds., Elsevier, **1994**, 175-205.

"Two-, Three-, and Four-Dimensional Nuclear Magnetic Resonance Spectroscopy of Protein Pharmaceuticals", David G. Vander Velde, James Matsuura, and Mark C. Manning, in Pharmaceutical Biotechnology, Volume 7, James Herron, Wim Jiskoot, and Daan J.A. Crommelin, Eds., Plenum Press, New York, **1995**, 179-218.

"Rational Approach to the Preformulation and Formulation of Protein Pharmaceuticals", Mark C. Manning, Eli Shefter, and John F. Carpenter, Peptide and Protein Drug Delivery, 2nd Edition, V.H.L. Lee, Ed., Marcel Dekker, **2002**, in press (peer reviewed).

"High Throughput Formulation: New Strategies for Developing Stable Protein Formulations", Rajiv Nayar and Mark C. Manning, in Pharmaceutical Biotechnology, Volume 13, John F. Carpenter and Mark C. Manning, Eds., Kluwer Academic/Plenum Press, New York, **2002**, 177-198 .

"Effect of Conformation on the Chemical Stability of Polypeptides", Jeffrey D. Meyer, Bert Ho, and Mark C. Manning, in Pharmaceutical Biotechnology, Volume 13, John F. Carpenter and Mark C. Manning, Eds., Kluwer Academic/Plenum Press, New York, **2002**, 85-107.

*E. Books*

Published as a faculty member :

"Stability of Protein Pharmaceuticals: Chemical and Physical Pathways of Protein Degradation", Volume 2 of Pharmaceutical Biotechnology, Tim J. Ahern and Mark C. Manning, Editors, Plenum Press, New York, 1992.

"Stability of Protein Pharmaceuticals: *in vivo* Pathways of Degradation and Strategies for Protein Stabilization", Volume 3 of Pharmaceutical Biotechnology, Tim J. Ahern and Mark C. Manning, Editors, Plenum Press, New York, 1992.

"Rational Design of Stable Protein Formulations: Theory and Practice", Volume 13 of Pharmaceutical Biotechnology, John F. Carpenter and Mark C. Manning, Editors, Plenum Press, New York, 2002.

*F. Abstracts*

"Preparation, Structure, and Reactivity of Metal Complexes Containing the Extremely Bulky Pseudohalides  $OTeF_5^-$  and  $OC(CF_3)_3^-$ ", Steven H. Strauss, Kent D. Abney, Mark D. Noirot, Mark R. Colsman, Patti K. Miller, and Mark C. Manning, Abstract 266, INOR Section, 190th Meeting of the American Chemical Society, Chicago, IL, September 8-13, 1985.

"Synthesis and Reactivity of Platinum and Palladium Teflate ( $OTeF_5^-$ ) Complexes", Mark R. Colsman, Mark C. Manning, Oren P. Anderson, and Steven H. Strauss, Abstract 409, INOR Section, 193rd Meeting of the American Chemical Society, Denver, CO, April 5-10, 1987.

"The Circular Dichroism of  $\alpha$  Helices. Determination of the Important Geometric and Electronic Factors", Mark C. Manning and Robert W. Woody, *Biophys. J.* **1987**, 51, 280a.

"Theoretical Investigations of the Spectroscopic Properties of Bent  $\alpha$  Helices", Thomas M. Cooper, Mark C. Manning, and Robert W. Woody, *Biophys. J.* **1987**, 51, 281a.

"Contribution of Aromatic Side-Chains to the Circular Dichroism of Bovine Pancreatic Trypsin Inhibitor: A Theoretical Study", Mark C. Manning and Robert W. Woody, *Biophys. J.* **1988**, 53, 96a.

"Solution Conformation of Beta Amino Acids. Calculation of the Circular Dichroism of Helical Poly( $\alpha$ -Isobutyl L-Aspartate)", Mark C. Manning, J.M. Fernandez-Santin, J. Puiggali, J.A. Subirana, and Robert W. Woody, *Biophys. J.* **1989**, 55, 530a.

Presentations as a faculty member:

"Influence of  $\alpha$ -Helical Structure on Deamidation of Asparagine Residues", Cynthia L. Stevenson, Mark C. Manning, and Ronald T. Borchardt, *Biophys. J.* **1989**, 55, 357a.

"Structural Control of Protein Deamidation. Peptide Models of the Deamidation Sites in Proteins", Kamlesh Patel, Cecilia Oliyai, Ronald T. Borchardt, and Mark C. Manning, *J. Cell. Biochem.* **1989**, Supplement 13A, Poster A318, p. 88.

"Deamidation: A Major Pathway for Chemical Degradation of Proteins and Peptides", R.T. Borchardt, K. Patel, N. Bhatt, C. Stevenson, and M. Manning, The Academy of Pharmaceutical Sciences and Technology Conference, Shirakaabako, Japan, July, 1989.

"Protein Stability: Effect of pH and Temperature on Activity and Conformation of Fibrolase", D. Pretzer, M.C. Manning, B.S. Schulteis, and J.W. Mitchell, Abstract, AAPS Western Regional Meeting, Reno, Nevada, February, 1990.

"In Vitro Studies of Peptide Transport Through a Cell Culture Model of the Blood-Brain Barrier", K.L. Audus and M.C. Manning, Abstract, XIth International Congress of Pharmacology, Amsterdam, The Netherlands, July, 1990, *Eur. J. Pharmacol.* **1990**, 183, 1636.

"Calculation of the Circular Dichroism Spectra of Protein Helices", Mark C. Manning and Robert W. Woody, Abstract, Satellite Meeting of the International Biophysics Congress on Expanding Frontiers in Polypeptide and Protein Structural Research, Whistler, British Columbia, July, 1990.

"Kinetics of Aspartate Degradation in Val-Tyr-Pro-Asp-Gly-Ala", Cecilia Oliyai, Mark C. Manning, and Ronald T. Borchardt, Abstract, AAPS National Meeting, Las Vegas, Nevada, November, 1990, *Pharmaceutical Res.* **1990**, 7, S-129.

"Improved Models for Aromatic Side Chain Contributions to Circular Dichroism Spectra", N. Sreerama, Mark C. Manning, and Robert W. Woody, Abstract, International Quantum Chemistry Conference, France, July, 1991.

"The Circular Dichroism of Biopolymers: Aromatic Side-Chain CD in Proteins", N. Sreerama, Mark C. Manning, and Robert W. Woody, Abstract, Fourth International Conference on Circular Dichroism, Bachen, Germany, August, 1991.

"Determination of the Solution Structure of Delta-Sleep-Inducing Peptide (DSIP)", Ronda Gray, David Vander Velde, Mark Manning, and Ronald T. Borchardt, Abstract BIOTEC 2051, AAPS National Meeting, *Pharmaceutical Res.* **1991**, 8, S-58.

"Evaluation of Free Energies of Alpha Helix Stabilization by Individual Side Chains", Pingchiang C. Lyu, Paul M. Gans, Mark Manning, Robert Woody, and Neville R. Kallenbach, *Biophys. J.* **1992**, 61, A348.

"Improved Models for Tyrosine and Phenylalanine Contributions to the Protein Circular Dichroism Spectra", M.C. Manning, N. Sreerama, and R.W. Woody, *Biophys. J.* **1992**, *61*, A347.

"Hydrophobic Ion Pairs: Sodium Dodecyl Sulfate (SDS)-Peptide Interactions", James Matsuura, Michael E. Powers, James Brassell, Mark C. Manning, and Eli Shefter, Fifth Colorado Biotechnology Symposium, Fort Collins, CO, September, 1992.

"The Effect of Primary Sequence on the Conformation of Delta-Sleep Inducing Peptide (DSIP)", R. Gray, D. Vander Velde, C. Burke, G. Sanyal, M. Manning, C.R. Middaugh, and R.T. Borchardt, Abstract BIOTEC 2016, AAPS National Meeting *Pharmaceutical Res.* **1992**, *9*, S-70.

"Conformation of Calcitonin Gene-Related Peptide(8-37) in Aqueous Solution", James Matsuura and Mark C. Manning, Abstract BIOTEC 2042, AAPS National Meeting, *Pharm. Res.* **1992**, *9*, S-77.

"Hydrophobic Ion Pairs: Sodium Dodecyl Sulfate (SDS)-Peptide Interactions", Michael E. Powers, James Matsuura, James Brassell, Mark C. Manning, and Eli Shefter, Abstract BIOTEC 2043, AAPS National Meeting, *Pharmaceutical Res.* **1992**, *9*, S-77.

"Alteration of Neuropeptide Properties through Hydrophobic Ion Pairing", James E. Matsuura, Michael E. Powers, Mark C. Manning, Eli Shefter, S. Mark Cox, and Gerald L. Yewey, Winter Neuropeptide Meeting, Breckenridge, CO, February, 1993.

"Enhancement of Protein Lipophilicity and Stability Via Hydrophobic Ion Pairing", James Matsuura, Michael E. Powers, Mark C. Manning, and Eli Shefter, Biochemical Technology Section, National ACS Meeting, Denver, CO, March, 1993.

"Optical Spectroscopy in the Analysis of Polypeptide Structure and Stability", James Matsuura, Michael E. Powers, Thomas Foster, Heather Thomas, Jonathon Dormish, John F. Carpenter, Merrick L. Shively, and Mark C. Manning, Rocky Mountain Analytical Conference, Pharmaceutical Analysis Division, Denver, CO, July, 1993.

"Enhancement of Enzyme Solubility in Organic Solvents Via Sodium Dodecyl Sulfate Ion Pairs", Brent S. Kendrick, James E. Matsuura, and Mark C. Manning, Pharmaceutics Graduate Student Research Meeting, Lincoln, NE, June, 1994.

"Enhancement of Protein Lipophilicity Via Sodium Dodecyl-Sulfate Ion Pairs", James E. Matsuura, Eli Shefter, and Mark C. Manning, Graduate Research Association of Students in Pharmaceutics (GRASP) Meeting, Lincoln, NE, June, 1994. (won first place award for best poster)

"Heat-Induced Gel Formation of  $\beta$ -Lactoglobulin: A Study on the Secondary and Tertiary Structure as Followed by Circular Dichroism Spectroscopy", James E. Matsuura and Mark C. Manning, Colorado Protein Stability Conference, Breckenridge, CO, July 1994.

"Use of Hydrophobic Ion Pairing (HIP) to Enhance the Delivery of Protein Pharmaceuticals from Biodegradable Polymers", Mark C. Manning, Jonathon Dormish, James E. Matsuura, Andrea Lloyd, Jeffrey D. Meyer, Ellen Duysen, S. Mark Cox, and Gerald L. Yewey, Seventh Annual Colorado Biotechnology Symposium, Fort Collins, CO, September, 1994.

"Enhancement of Enzyme Solubility in Organic Solvents Via Hydrophobic Ion Pairing", Jeffrey D. Meyer, Brent S. Kendrick, James E. Matsuura, and Mark C. Manning, Seventh Annual Colorado Biotechnology Symposium, Fort Collins, CO, September, 1994.

"Peptide Structure in Organic Solvents by Circular Dichroism and FTIR Spectroscopy", James E. Matsuura and Mark C. Manning, Seventh Annual Colorado Biotechnology Symposium, Fort Collins, CO, September, 1994.

"The Structure of Hydrophobic Ion Paired Peptides and Proteins in Organic Solvents", James E. Matsuura, Brent S. Kendrick, Jeff Meyer, and Mark C. Manning, *Biophys. J.* 1995, 68, A340.

"Approaches for Increasing the Stability of Proteins", Eli Shefter, Mark C. Manning, and John F. Carpenter, Parenteral Drug Association Spring National Meeting, San Francisco, CA, March, 1995.

"NMR and CD Conformational Studies of Leuprolide Acetate", David G. Vander Velde, Mark C. Manning, James Matsuura, and Jeffrey Meyer, Experimental Nuclear Magnetic Resonance Conference, Boston, MA, March, 1995.

"Structure-Activity Studies of Position 14 of CGRP", D. David Smith, Jianzhong Li, James Matsuura, Thomas E. Adrian, and Mark C. Manning, Fourteenth American Peptide Symposium, Columbus, Ohio, June, 1995.

"Production of Submicron-Sized Particles of Ionic Pharmaceuticals Using a Modification to the Gas Antisolvent Precipitation Process", Rick Falk, Ted Randolph, Jeffrey D. Meyer, R. Michael Kelly, and Mark C. Manning, Eighth Annual Colorado Biotechnology Symposium, Boulder, CO, September, 1995.

"Infrared Spectroscopic Study of Structural Differences in  $\beta$ -Lactoglobulin Genetic Variants", A. Dong, J. Matsuura, S. D. Allison, E. Chrisman, M. C. Manning, and J. F. Carpenter, Abstract BIOTEC 2029, AAPS National Meeting, Miami, FL, November, 1995, *Pharmaceutical Res.* 1995, 12, S-86.

"Hydrophobic Ion Pairing (HIP) Subtilisin BPN' Results in Structural Stabilization during Lyophilization and Increased Activity in Isooctane and Ethanol", Brent Kendrick, Jeffrey Meyer, James Matsuura, John F. Carpenter, and Mark C. Manning, Abstract BIOTEC 2076, AAPS National Meeting, Miami, FL, November, 1995, *Pharmaceutical Res.* **1995**, 12, S-97.

"Production of Submicron-Sized Particles of Ionic Pharmaceuticals Using a Modification to the Gas Antisolvent Precipitation Process", Rick Falk, Theodore W. Randolph, Mark Manning, Jeffrey D. Meyer, and R. Michael Kelly, American Institute of Chemical Engineers National Meeting, Miami, FL, November, 1995.

"Secondary Structure and Thermal Stability of Recombinant Human Factor XIII in Aqueous Solution", A. Dong, L. Kreilgård, B. Kendrick, J. Matsuura, M.C. Manning, and J.F. Carpenter, Poster Tu-Pos243, 40th Annual Meeting, Biophysical Society, Baltimore, MD, February, 1996, *Biophys. J.* **1996**, 70, A305.

"Controlled Release of Ionic Pharmaceuticals from Poly(L-lactide) Microspheres Prepared by Precipitation with a Compressed Antisolvent", Richard F. Falk, Theodore W. Randolph, Jeffrey D. Meyer, R. Michael Kelly, and Mark C. Manning, Fourth European Symposium on Controlled Drug Delivery, Nordwijk, Netherlands, April 3-5, 1996.

"Tween 20" Prevents Freeze-Thawing and Shaking-Induced Denaturation: A Mechanistic Study on Protein-Surfactant Interactions", L. Kreilgård, L. S. Jones, T.W. Randolph, S. Frøkjaer, J.M. Flink, M. C. Manning, J. C. Nadler, and J. F. Carpenter, Colorado Protein Stability Conference, Breckenridge, Colorado, July, 1996.

"IR and CD Spectroscopic Structural Study of rhIFN- $\gamma$  Aggregates Induced by Chemical and Thermal Stresses", B. S. Kendrick, J. Cleland, X. Lam, T. Nguyen, T. Randolph, M. C. Manning, and J. F. Carpenter, Colorado Protein Stability Conference, Breckenridge, Colorado, July, 1996.

"Solution Behavior of Human Corticotropin Releasing Hormone", J. D. Meyer, B. Ho, D. Snyder, and M. C. Manning, Colorado Protein Stability Conference, Breckenridge, Colorado, July, 1996.

"Position 14 of Human  $\alpha$ -Calcitonin Gene-Related Peptide (h- $\alpha$ -CGRP)", Jianzhong Li, James E. Matsuura, David J.J. Waugh, Ann M. Hanly, Thomas E. Adrian, Charles S. Bockman, Peter W. Abel, Mark C. Manning, and D. David Smith, 24th Symposium of the European Peptide Society, Edinburgh, Scotland, United Kingdom, September, 1996.

"Solution Behavior of Human Corticotropin Releasing Factor", Jeffrey D. Meyer, Bert Ho, Sheridan Snyder, and Mark C. Manning, Ninth Colorado Biotechnology Symposium, Fort Collins, CO, October, 1996.

"Incorporation of Ionic Pharmaceuticals into Poly(Lactide) Microspheres Using a Combination of Hydrophobic Ion Pairing and Supercritical Fluid Technology", Mark C. Manning, Jeffrey D. Meyer, R. Michael Kelly, Richard Falk, Theodore W. Randolph, Nicole Earhart, William Dernell, and Stephen Withrow, Ninth Colorado Biotechnology Symposium, Fort Collins, CO, October, 1996.

"Preparation and Release Characteristics of Gentamycin-Loaded Poly(L-lactide) Beads: A Possible Treatment for Osteomyelitis", Rick Falk, Jeffrey D. Meyer, R. Michael Kelly, Theodore W. Randolph, Willima Dernell, Stephen Withrow, and Mark C. Manning, Ninth Colorado Biotechnology Symposium, Fort Collins, CO, October, 1996.

"IR and CD Spectroscopic Structural Study of Soluble and Insoluble Aggregates of rhIFN- $\gamma$  Induced by Chemical and Thermal Stresses", Brent S. Kendrick, Jeffrey L. Cleland, Tue Nguyen, Theodore W. Randolph, Mark C. Manning, and John F. Carpenter, Abstract BIOTEC 2083, AAPS National Meeting, Seattle, WA, October, 1996, *Pharmaceutical Res.* **1996**, 13, S-97.

"Novel Cationic Detergents for Delivery of Oligonucleotide Therapeutics", Robert Beauvais, Jeffrey D. Meyer, Tessa Brandt, David Claffey, Eli Shefter, David J. Kroll, James A. Ruth, and Mark C. Manning, Abstract PDD 7617, AAPS National Meeting, Seattle, WA, October, 1996, *Pharmaceutical Res.* **1996**, 13, S-387.

"Nanoparticle Uptake by Alveolar Macrophages: A Potential Approach for Treatment of Tuberculosis", Ka-Yun Ng, Jeffrey D. Meyer, Richard F. Falk, David C. Thompson, Theodore W. Randolph, and Mark C. Manning, Abstract PT 6003, AAPS National Meeting, Seattle, WA, October, 1996, *Pharmaceutical Res.* **1996**, 13, S-157.

"Solution Behavior of Human Corticotropin Releasing Factor", Jeffrey D. Meyer, Bert Ho, Sheridan Snyder, and Mark C. Manning, Abstract BIOTEC 2093, AAPS National Meeting, Seattle, WA, October, 1996, *Pharmaceutical Res.* **1996**, 13, S-100.

"In Vitro Release Kinetics of Gentamycin from a Hyaluronic Acid Gel Delivery System for the Treatment of Peripheral Vestibular Disease", Jeffrey D. Meyer, R. Michael Kelly, Eli Shefter, Daniel C. Malone, James E. Matsuura, and Mark C. Manning, Abstract PDD 7243, AAPS National Meeting, Seattle, WA, October, 1996, *Pharmaceutical Res.* **1996**, 13, S-293.

"Effect of Secondary Structure on the Activity of Enzymes Suspended in Nonaqueous Solvents", Jeffrey D. Meyer, Aichun Dong, Brent S. Kendrick, Mark C. Manning, and John F. Carpenter, Abstract BIOTEC 2079, AAPS National Meeting, Seattle, WA, October, 1996, *Pharmaceutical Res.* **1996**, 13, S-96.

"Incorporation and In Vitro Release of Gentamicin in Poly(L-Lactide (PLA): A Possible Treatment for Osteomyelitis", Jeffrey D. Meyer, Richard F. Falk, Theodore W. Randolph, William Dernell, Stephen Withrow, and Mark C. Manning, Abstract PDD 7242, AAPS National Meeting, Seattle, WA, October, 1996, *Pharmaceutical Res.* **1996**, 13, S-293.

"Tyrosine and Phenylalanine Contributions to the Circular Dichroism of Proteins: CD Spectra of Wild-Type and Mutant BPTI", Narasimha Sreerama, Michael E. Powers, Mark C. Manning, David Goldenberg, and Robert W. Woody, Seventh International Conference of Circular Dichroism, Pisa, Italy, September, 1997.

"Chemical Stability of Peptide Drugs in Complex Dosage Forms: Deamidation of a Model Peptide in Pluronic Gels and Sucrose Solutions", Lewis Stratton, R. Michael Kelly, Jared Rowe, Jesse Shively, John F. Carpenter, and Mark C. Manning, Colorado Biopharmaceutical Delivery Conference, Breckenridge, CO, July, 1997.

"Antibiotic-Impregnated Biodegradable Implants Useful for the Treatment of Osteomyelitis", Rick Falk, Ted Randolph, Jeffrey D. Meyer, R. Michael Kelly, David J. Kroll, William Dernell, Stephen J. Withrow, and Mark C. Manning, Colorado Biopharmaceutical Delivery Conference, Breckenridge, CO, July, 1997.

"Evaluation of Cisplatin in Combination with a Biologic Response Modifier in a Rodent Mammary Carcinoma Model", E. Morello, W.S. Dernell, C.A. Kuntz, A. Nelson, M.C. Manning, N. Ehrhart, M. Lafferty, and S.J. Withrow, Tenth Colorado Biotechnology Symposium, Boulder, CO, September, 1997.

"Effect of Excipients on the Deamidation of a Model Peptide", Mark C. Manning, Lewis P. Stratton, Michael Kelly and John F. Carpenter, Abstract 2407, AAPS National Meeting, Boston, MA, November 1997, *Pharmaceutical Res.* **1997**, 14, S-351.

"Different Effect of Stabilizers against Freezing and Freeze-Drying Induced Secondary Structural Change of beta-Lactoglobulin B", K. Izutsu, M.C. Manning, and J.F. Carpenter, Abstract 2406, AAPS National Meeting, Boston, MA, November 1997, *Pharmaceutical Res.* **1997**, 14, S-351.

"Drug Delivery Matrix Containing Native Protein Precipitates Suspended in Poloxamer Gel", Lewis P. Stratton, Aichun Dong, Mark C. Manning, and John F. Carpenter, Abstract 2408, AAPS National Meeting, Boston, MA, November 1997, *Pharmaceutical Res.* **1997**, 14, S-351.

"Effect of Sucrose on the Stability and Conformational Dynamics of Recombinant Human Interleukin-1 Receptor Antagonist in Solution", Brent S. Kendrick, Byeong, S. Chang, Tsutomu Arakawa, Ted Randolph, Brian Peterson, Mark C. Manning, and John F. Carpenter, Abstract 1478, AAPS National Meeting, Boston, MA, November 1997, *Pharmaceutical Res.* **1997**, 14, S-162.

"Inactivation and Structural Perturbations Accompanying the Cold-Induced Dissociation of Glyceraldehyde-3-Phosphate Dehydrogenase in the Presence of Different Excipients", Katherine A. Pikal, Mark C. Manning, and John F. Carpenter, Abstract 3027, AAPS National Meeting, Boston, MA, November 1997, *Pharmaceutical Res.* **1997**, 14, S-471.

"Solution Behavior of Human Corticotropin Releasing Factor", Jeffrey D. Meyer, Bert Ho, and Mark C. Manning, Beckman Symposium on Solution Interaction of Macromolecules, Galveston, TX, November, 1997.

"Preparation of a Biodegradable Implant for the Treatment of Osteomyelitis using Precipitation with Supercritical Carbon Dioxide", Rick Falk, Jeffrey D. Meyer, Theodore W. Randolph, William S. Dernell, and Mark C. Manning, American Institute of Chemical Engineers Annual Meeting, Paper 109e, Los Angeles, CA, November, 1997.

"Evaluation of Cisplatin in Combination with a Biologic Response Modifier in a Rodent Mammary Carcinoma Model", E. Morello, W.S. Dernell, C.A. Kuntz, A. Nelson, M.C. Manning, N. Ehrhart, M. Lafferty, and S.J. Withrow, Veterinary Cancer Society Meeting, Chicago, IL, December, 1997.

"Solution Behavior of Human Corticotropin Releasing Factor", Jeffrey D. Meyer, Bert Ho, and Mark C. Manning, Annual Student Research Forum, University of Colorado Health Sciences Center, Denver, CO, January, 1998.

"The DNA Packaging Enzyme of Phage  $\lambda$ : Dimerization and Oligomerization of the Small Subunit May Involve a Hydrophobic Interface and Intermolecular Disulfide Bond", J.D. Meyer, A. Hanagan, M.C. Manning, and C.E. Catalano, 42nd Biophysical Society Annual Meeting, Poster M-Pos168, Kansas City, MO, February, 1998, *Biophys. J.* **1998**, 74, A72.

"Tyrosine, Phenylalanine and Disulfide Contributions to the Circular Dichroism of Proteins: CD Spectra of Wild-Type and Mutant BPTI", N. Sreerama, M.E. Powers, M.C. Manning, D.M. Goldenberg, and R.W. Woody, 42nd Biophysical Society Annual Meeting, Poster M-Pos116, Kansas City, MO, February, 1998, *Biophys. J.* **1998**, 74, A63.

"Comparative Infrared and CD Spectroscopic Analysis of  $\alpha_1$ -Protease Inhibitor and Ovalbumin", A. Dong, J.D. Meyer, M.C. Manning, J. Brown, and J.F. Carpenter, 42nd Biophysical Society Annual Meeting, Poster W-Pos127, Kansas City, MO, February, 1998, *Biophys. J.* **1998**, 74, A277.

"In Vitro and In Vivo Evaluation of Gentamicin-Impregnated Polylactic Acid Beads", W.S. Dernell, J.D. Meyer, R.F. Falk, R.M. Kelly, J.E. Shively, D.J. Kroll, T.W. Randolph, M.C. Manning, C.A. Kuntz, R. Dewell, B.E. Powers, S.J. Withrow, and F.B. Garry, Veterinary Orthopedic Society Meeting, Snowmass, CO, February, 1998.

"In Vitro and In Vivo Evaluation of Gentamicin-Impregnated Polylactic Acid Beads", W.S. Dernell, J.D. Meyer, R.F. Falk, R.M. Kelly, J.E. Shively, D.J. Kroll, T.W. Randolph, M.C. Manning, C.A. Kuntz, R. Dewell, B.E. Powers, S.J. Withrow, and F.B. Garry, 44th Annual Meeting of the Orthopaedic Research Society, New Orleans, LA, March, 1998.

"Solution Behavior of Human Corticotropin Releasing Factor", Jeffrey D. Meyer, Bert Ho, and Mark C. Manning, Pharmaceutics Graduate Student Research Meeting, Lawrence, KS, June, 1998.

"Hydrophobic Ion Pairing (HIP) of Compounds Containing a Single Positive Charge. The Effect of Solution Conditions on Ion-Paired Complex Formation", Jessica Stern, Susan J. Manning, Emily Evans, Jeffrey D. Meyer, Eli Shefter, Theodore W. Randolph, Gerald L. Yewey, and Mark C. Manning, Merck Undergraduate Research Seminar, Estes Park, CO, June, 1998.

"Detection of Structural Changes in Nucleotide-Based Therapeutics using Circular Dichroism Spectroscopy", Sambou S. Jatta, Robert M. Beauvais, Thomas J. Anchordoquy, and Mark C. Manning, Merck Undergraduate Research Seminar, Estes Park, CO, June, 1998.

"Cos-7 Transfection with Polyamidoamine Dendrimers: A Comparative Study", Robert Serravo, Bin Tain, Mark Manning, David Kroll, Tom Anchordoquy, and Lawrence Ng, Merck Undergraduate Research Seminar, Estes Park, CO, June, 1998.

"Comparative FT-IR and CD Spectroscopic Analysis of  $\alpha_1$ -Proteinase Inhibitor and Ovalbumin", Aichun Dong, Jeffrey D. Meyer, Jerry L. Brown, Mark C. Manning, and John F. Carpenter, Colorado Protein Stability Conference, Breckenridge, CO, July, 1998.

"In vivo Evaluation of Antibiotic-Impregnated Beads in a Rat Osteomyelitis Model", W.S. Dernell, S.J. Withrow, C.A. Kuntz, M. Lafferty, B.E. Powers, M.C. Manning, J.E. Shively, J.D. Meyer, R.F. Falk, and T.W. Randolph, Eleventh Annual Colorado Biotechnology Symposium, Fort Collins, CO, September, 1998.

"Evaluation of Intracavitary Slow Release Paclitaxel Chemotherapy in a Rodent Model of Breast Cancer", V.S. Bregazzi, W.S. Dernell, D.J. Huber, S.J. Withrow, G.K. Ogilvie, M. Manning, B.E. Powers, R. Schochet, and M. Lafferty, 18th Annual Meeting of the Veterinary Cancer Society, Estes Park, CO, October, 1998.

"Assessment of DNA Structure within Non-Viral Delivery Systems by Fourier Transform Infrared Spectroscopy", T. Anchordoquy, S.D. Allison, J.-J. Lin, M.C. Manning, and J.F. Carpenter, Abstract 2500, AAPS National Meeting, San Francisco, CA, November 1998, *PharmSci* 1998, 1, S-281.

"Structural Characterization of Human Growth Hormone Subjected to Zinc-Induced Precipitation", Tzung-Horng Yang, Jeffrey L. Cleland, Theodore W. Randolph, Mark C. Manning, and John F. Carpenter, Abstract 3614, AAPS National Meeting, San Francisco, CA, November 1998, *PharmSci* **1998**, 1, S-536.

"Aggregation of Human Serum Albumin during Bioprocessing", Jen-Jen Lin, Jeffrey D. Meyer, John F. Carpenter, and Mark C. Manning, Abstract 21, Western Regional AAPS Meeting, San Diego, CA, April, 1999.

""Biophysical and Biochemical Characterization of a DNA Binding Domain of gpNu1, a Phage  $\lambda$  Packaging Protein", Q. Yang, T. de Beer, J. Baran, M.C. Manning, M. Overduin, and C.E. Catalano, Poster M-Pos140, Biophysical Society Meeting, Baltimore, MD, February, 1999, *Biophys. J.* **1999**, 76, A177.

"Sample Processing Concerns for Solid Proteins in FTIR Spectroscopy", Jeffrey D. Meyer, Mark C. Manning, and John F. Carpenter, Poster PS 16, 31st Pharmaceutics Graduate Student Research Meeting, Kansas City, KS, June, 1999.

"Effect of Crystallinity on Activation of Alveolar Macrophage Cells by Poly(L-lactide) and Poly(lactide-co-glycolide) Microparticles", D.L. Biggs, C.S. Lengsfeld, L.K. Ng, M. Manning, and T. Randolph, Colorado Macromolecular Drug Delivery Conference, Breckenridge, CO, July, 1999.

"Comparison of Effects of a Non-specific Stabilizing Solute and a Specific Ligand on Conformational Dynamics of Ribonuclease A and S", Y.-S. Kim, B.S. Chang, B.S. Kendrick, T.W. Randolph, M. Manning, and J.F. Carpenter, Colorado Macromolecular Drug Delivery Conference, Breckenridge, CO, July, 1999.

"Aggregation of Human Serum Albumin during Bioprocessing", Jen-Jen Lin, Jeffrey D. Meyer, John F. Carpenter, and Mark C. Manning, Paper 3.5, Twelfth Annual Colorado Biotechnology Symposium, Boulder, CO, September, 1999.

"Sample Processing Concerns for Solid Proteins in FTIR Spectroscopy", Jeffrey D. Meyer, Mark C. Manning, and John F. Carpenter, Poster 11, Twelfth Annual Colorado Biotechnology Symposium, Boulder, CO, September, 1999.

"Effect of Poly(L-lactide) Microparticle Crystallinity on Macrophage Inflammatory Response", Danielle L. Biggs, Corrine S. Lengsfeld, Theodore W. Randolph, L.K. Ng, and Mark Manning, Poster 45, Twelfth Annual Colorado Biotechnology Symposium, Boulder, CO, September, 1999.

"Comparison of Effects of a Non-specific Stabilizing Solute and a Specific Ligand on Conformational Dynamics of Ribonuclease A and S", Yong-Sung Kim, Mark Manning, John F. Carpenter, Byeong S. Chang, Brent S. Kendrick, and Theodore W. Randolph, Poster 53, Twelfth Annual Colorado Biotechnology Symposium, Boulder, CO, September, 1999.

"In Vivo Evaluation of Antibiotic-Impregnated Beads in a Rat Osteomyelitis Model", W.S. Dernell, S.J. Withrow, M.C. Manning, C.A. Kuntz, M. Lafferty, B.E. Powers, J.E. Shively, R.F. Falk, J.D. Meyer, and T.W. Randolph, American College of Veterinary Surgeons National Meeting, San Francisco, CA, September, 1999.

"Effect of Poly(l-lactide) Microparticle Crystallinity on Alveolar Macrophage Inflammatory Response", Danielle Biggs, Corinne Lengsfeld, Mark C. Manning, Ka-yun Ng, and Theodore Randolph, 29th Annual Biochemical Engineering Symposium, Norman, OK, October, 1999.

"Sucrose Induces More Restricted Conformational Fluctuations of Ribonuclease A and S and Cytochrome c", Y.S. Kim, L.S. Jones, A. Dong, B.S. Chang, M.C. Manning, and J.F. Carpenter, Poster 3726, AAPS National Meeting, New Orleans, LA, November, 1999, *PharmSci* 1999, 1, S-2465.

"Aggregation of Human Serum Albumin during Bioprocessing", J.J. Lin, J.D. Meyer, J.F. Carpenter, and M.C. Manning, Poster 3452, AAPS National Meeting, New Orleans, LA, November, 1999, *PharmSci* 1999, 1, S-2172.

"Irreversible Protein Aggregation under Physiological Conditions: Characterization and Thermodynamic Inhibition", S. Krishnan, E. Chi, J. Webb, B.S. Chang, M.C. Manning, T.W. Randolph and J.F. Carpenter, FASEB Summer Research Conference: Amyloids and Other Protein Misfolding Diseases", Copper Mountain, CO, June, 2000.

"Counteracting Effects of Renal Solutes on Amyloid Fibril Formation by Immunoglobulin Light Chains", Yong-Sung Kim, Stephen P. Cape, Eva Chi, Rosemarie Raffen, Priscilla W. Stevens, Fred J. Stevens, Alan Solomon, Mark C. Manning, Theodore W. Randolph, and John F. Carpenter, FASEB Summer Research Conference: Amyloids and Other Protein Misfolding Diseases", Copper Mountain, CO, June, 2000.

"Counteracting Effects of Renal Solutes on Amyloid Fibril Formation by Immunoglobulin Light Chains", Yong-sung Kim, Stephen P. Cape, Eva Chi, Rosemarie Raffen, Priscilla W. Stevens, Fred J. Stevens, Alan Solomon, Mark C. Manning, Theodore W. Randolph, and John F. Carpenter, Colorado Protein Stability Conference, Breckenridge, CO, July, 2000.

"Precipitation of a Model Protein by Hyaluronic Acid and Its Derivatives", Lixin Feng, Derrick S. Katayama, and Mark C. Manning, Colorado Protein Stability Conference, Breckenridge, CO, July, 2000.

"Irreversible Protein Aggregation under Physiological Conditions: Thermodynamic Inhibition and Characterization", Sampathkumar Krishnan, Eva Chi, Jonathon Webb, Byeong S. Chang, Mark C. Manning, Theodore W. Randolph, and John F. Carpenter, Colorado Protein Stability Conference, Breckenridge, CO, July, 2000.

"Structural Control of Methionine Oxidation in Human Corticotropin Releasing Factor" Jeffrey D. Meyer, Bert Ho, and Mark C. Manning, Colorado Protein Stability Conference, Breckenridge, CO, July, 2000.

"Vertebral Osteomyelitis in a Bottlenose Dolphin, *Tursiops truncatus*: A Novel Treatment using Sustained Release, Antibiotic-Impregnated, Biodegradable Microspheres", Caroline E.C. Goertz, J. Lawrence Dunn, Mark C. Manning, Theodore W. Randolph, Derrick Katayama, Danielle Biggs, Rod Cole, Adam Brockman, Johnny Cardinnes, and David J. St. Rubin, American Association of Zoo Veterinarians and International Aquatic Animal Medicine Joint Annual Conference, New Orleans, LA, September, 2000.

"Effect of Poly(L-lactide) Microparticle Crystallinity on Alveolar Macrophage Activation" Danielle Biggs, Theodore W. Randolph, Ka-yun Ng, Brooks Hybertson, and Mark C. Manning, Thirteenth Annual Colorado Biotechnology Symposium, Fort Collins, CO, September, 2000.

"Counteracting Effects of Renal Solutes on Amyloid Fibril Formation by Immunoglobulin Light Chains", Yong-sung Kim, Mark C. Manning, John F. Carpenter, Stephen P. Cape, Eva Chi, Theodore W. Randolph, Rosemarie Raffen, Priscilla W. Stevens, Fred J. Stevens, and Alan Solomon, Thirteenth Annual Colorado Biotechnology Symposium, Fort Collins, CO, September, 2000.

"Systemic Paclitaxel Delivery using a Poloxamer-Based Aqueous Suspension: A Pharmacokinetic Study", Lixin Feng, Charles L. Hughes, William S. Dernell, Mark W. Duncan, and Mark C. Manning, Poster 3524, AAPS National Meeting, Indianapolis, IN, November, 2000.

"Ion Pairing of Therapeutic Agents using a Prodrug Approach: Study of Isoniazid Sulfonate", Huiyu Zhou, David J. Claffey, James A. Ruth, Ka-yun Ng, Theodore W. Randolph, and Mark C. Manning, Poster 2525, AAPS National Meeting, Indianapolis, IN, November, 2000.

"Enhanced Potency of Ion-Paired Complexes of Cis-platin and Tetracycline", Lixin Feng, Danielle L. Biggs, Derrick S. Katayama, Ka-yun Ng, William S. Dernell, Theodore W. Randolph, and Mark C. Manning, Poster 3304, AAPS National Meeting, Indianapolis, IN, November, 2000.

"Effect of Poly(L-lactide) Microparticle Crystallinity on Alveolar Macrophage Activation", Danielle L. Biggs, Corinne S. Lengsfeld, Brooks M. Hyberston, Ka-yun Ng, Mark C. Manning, and Theodore W. Randolph, Poster 2123, AAPS National Meeting, Indianapolis, IN, November, 2000.

"Effects of Sample Processing on Lyophilized Proteins Analyzed by Infrared Spectroscopy", Jeffrey D. Meyer, John F. Carpenter, and Mark C. Manning, Poster 2388, AAPS National Meeting, Indianapolis, IN, November, 2000.

"Structural Control of Methionine Oxidation in Human Corticotropin Releasing Factor", Jeffrey D. Meyer, Bert Ho, and Mark C. Manning, Poster 2275, AAPS National Meeting, Indianapolis, IN, November, 2000.

"Irreversible Protein Aggregation under Physiological Conditions: Characterization and Thermodynamic Inhibition", S. Krishnan, E. Chi, J. Webb, B.S. Chang, M.C. Manning, T.W. Randolph and J.F. Carpenter, Colorado Alliance for Bioengineering Day at Fitzsimons, Aurora, CO, December, 2000.

"Counteracting Effects of Renal Solutes on Amyloid Fibril Formation by Immunoglobulin Light Chains", Yong-Sung Kim, Stephen P. Cape, Eva Chi, Rosemarie Raffen, Priscilla W. Stevens, Fred J. Stevens, Alan Solomon, Mark C. Manning, Theodore W. Randolph, and John F. Carpenter, Colorado Alliance for Bioengineering Day at Fitzsimons, Aurora, CO, December, 2000.

"Enhanced Efficacy of Ion-Paired Tetracycline" D. Biggs, C. Lengsfeld, M. Manning, and T. Randolph, Controlled Release Society Annual Meeting, San Diego, CA, June, 2001.

"Cellular Response to Poly(L-Lactide) Microparticles for Pulmonary Delivery", D. Biggs, C. Lengsfeld, B. Hybertson, L.K. Ng, M. Manning, and T. Randolph, Controlled Release Society Annual Meeting, San Diego, CA, June, 2001.

"Polymeric Microspheres in Gene Delivery: A DNA Release and Polymer Degradation Study", Mayank M. Patel, Thomas J. Anchordoquy, Theodore W. Randolph, and Mark C. Manning, Colorado Macromolecular Drug Delivery Conference, Breckenridge, CO, July, 2001.

"Cellular Response to Poly(L-Lactide) Microparticles for Pulmonary Delivery", Danielle L. Biggs, Corinne S. Lengsfeld, Brooks M. Hybertson, Lawrence K. Ng, Mark C. Manning, and Theodore W. Randolph, Colorado Macromolecular Drug Delivery Conference, Breckenridge, CO, July, 2001.

"Release Kinetics of Isoniazid Methanesulfonate from Poly(L-Lactide) Microspheres Produced by Precipitation with a Compressed Antisolvent", Huiyu Zhou, Danielle L. Biggs, David J. Claffey, James A. Ruth, Theodore W. Randolph, Lawrence K. Ng, and Mark C. Manning, Colorado Macromolecular Drug Delivery Conference, Breckenridge, CO, July, 2001.

"In Vitro and In Vivo Assessment of a Hydrophobic Ion Paired (HIP) Complex of Vancomycin", Lixin Feng, Derrick Katayama, Vicki J. Jameson, J. Shively, William S. Dernell, Theodore W. Randolph, and Mark C. Manning, Colorado Macromolecular Drug Delivery Conference, Breckenridge, CO, July, 2001.

**“Cellular Response to Poly(L-Lactide) Microparticles for Pulmonary Delivery”, Danielle L. Biggs, Brooks Hybertson, Corinne S. Lengsfeld, Ka-yun L. Ng, Mark C. Manning, and Theodore W. Randolph, Poster T3515, AAPS National Meeting, Denver, CO, October, 2001.**

**“A Microtiter Plate-Based Assay of Protein Solubility: Measurements with Less Material and Less Time”, Derrick S. Katayama and Mark C. Manning, Poster R5257, AAPS National Meeting, Denver, CO, October, 2001.**

**“In Vitro and In Vivo Assessment of a Hydrophobic Ion Paired (HIP) Complex of Vancomycin”, Lixin Feng, Derrick Katayama, Jesse Shively, Theodore W. Randolph, William S. Dernell, and Mark C. Manning, Poster T3761, AAPS National Meeting, Denver, CO, October, 2001.**

**“High Throughput Formulation: Nonisothermal Stress Testing of Biopharmaceuticals”, L. Steve Mitchell, Derrick Katayama, Rajiv Nayar, and Mark C. Manning, Poster M2371, AAPS National Meeting, Denver, CO, October, 2001.**

**“Localized Delivery of Paclitaxel Using an Aqueous Poloxamer Gel: An Efficacy Study”, Lixin Feng, William S. Dernell, Vicki J. Jameson, and Mark C. Manning, Poster W4327, AAPS National Meeting, Denver, CO, October, 2001.**

**“Characterization of Lipid-DNA Interactions by Fluorescence Resonance Energy Transfer, Anisotropy, and Circular Dichroism”, Ye Zhang, William Garzon-Rodriguez, Mark C. Manning, and Thomas J. Anchordoquy, Poster M 2354, AAPS National Meeting, Denver, CO, October, 2001.**

**“Aggregation of Human Serum Albumin under Different Stresses: Effect of Pressure and Non-Specific Solutes”, Sampathkumar Krishnan, Richard S. St. John, Mark C. Manning, Theodore W. Randolph, and John F. Carpenter, Poster M2362, AAPS National Meeting, Denver, CO, October, 2001.**

**“A Mechanistic Study of Benzyl Alcohol-Induced Aggregation of a Predominantly Beta-Sheet Model Protein”, LaToya S. Jones, Byeong S. Chang, Mark C. Manning, Theodore W. Randolph, and John F. Carpenter, Poster M2297, AAPS National Meeting, Denver, CO, October, 2001.**

**“Characterization and Thermodynamic Inhibition of Aggregation of Granulocyte Colony Stimulating Factor under Physiological Conditions”, Sampathkumar Krishnan, Eva Y. Chi, Jonathan S. Webb, Byeong S. Chang, Mark C. Manning, Theodore W. Randolph, and John F. Carpenter, Poster M2349, AAPS National Meeting, Denver, CO, October, 2001.**

**“Combinations of Bulking Agents and Sucrose in the Lyophilization of a Monoclonal Antibody: A Computer-Aided Design of Experiment Study” Jeffrey D. Meyer, Rajiv Nayar, John F. Carpenter, and Mark C. Manning, Poster M2204, AAPS National Meeting, Denver, CO, October, 2001.**

**“Release Kinetics of Isoniazid Methanesulfonate from Poly(L-Lactide) Microspheres Produced by Precipitation with a Compressed Antisolvent”, Huiyu Zhou, Danielle L. Biggs, Theodore W. Randolph, Ka-yun Ng, and Mark C. Manning, Poster T 3367, AAPS National Meeting, Denver, CO, October, 2001.**

**“Polymeric Microspheres in Gene Delivery: A DNA Release and Polymer Degradation Study”, Mayank M. Patel, Thomas J. Anchordoquy, Theodore W. Randolph, and Mark C. Manning, Poster W4758, AAPS National Meeting, Denver, CO, October, 2001.**

**“Enhanced Efficacy of Ion-Paired Tetracycline”, Danielle L. Biggs, Corinne S. Lengsfeld, Mark C. Manning, and Theodore W. Randolph, Poster W4759, AAPS National Meeting, Denver, CO, October, 2001.**

**“Suitability of Electrostatic Spraying for Macromolecular Therapeutics”, C.S. Lengsfeld, Y. Lentz, T. Anchordoquy, D. Dunn-Rankin, and M.C. Manning, ILASS Americas, 15<sup>th</sup> Annual Conference on Liquid Atomization and Spray Systems, Madison, WI, May, 2002.**

**“Retrospective Statistical Analysis of Lyophilized Protein Formulations of Progenipoitin Using PLS. Determination of the Critical Parameters for Long-Term Storage Stability”, Derrick S. Katayama, Carol. F. Kirchhoff, Carrie M. Elliott, Robert Johnson, Jeffry Borgmeyer, Barrett R. Thiele, David L. Zeng, Hong Qi, John D. Ludwig, and Mark C. Manning, Colorado Protein Stability Conference, Breckenridge, CO, July, 2002.**

**“Stability of Human Serum Albumin in Solution under Different Stresses: Kinetics, Thermodynamics and Structural Transitions”, Sampathkumar Krishnan, K. Sudhinra Rao, Rick St. John, Theodore W. Randolph, Mark C. Manning, and John F. Carpenter, Colorado Protein Stability Conference, Breckenridge, CO, July, 2002.**

**“Thermodynamics of Congo Red Binding to an Amyloidogenic Protein and Its Effects on Amyloid Fibril Formation of the Protein”, Yong-sung Kim, Theodore W. Randolph, Fred J. Stevens, Mark C. Manning, and John F. Carpenter, Colorado Protein Stability Conference, Breckenridge, CO, July, 2002.**

**“Application of Near Infrared Spectroscopy to Measuring the Crystallinity of Glycine in Freeze-Dried Samples”, Shujun Bai, Rajiv Nayar, John F. Carpenter, and Mark C. Manning, Colorado Protein Stability Conference, Breckenridge, CO, July, 2002.**

"Applications of Gas-Phase Electrophoretic Mobility Molecular Analysis (GEMMA) in the Study of Protein Stability and Aggregation", Danny K.C. Chou, Theodore W. Randolph, and Mark C. Manning, Colorado Protein Stability Conference, Breckenridge, CO, July, 2002.

"Incorporation of Isoniazid into Poly(L-Lactide) Microspheres using a Prodrug Approach", Huiyu Zhou, Danielle L. Biggs, Daniel Jarmer, David J. Claffey, James A. Ruth, Theodore W. Randolph, Ka-yun Ng, and Mark C. Manning, Global Pharmaceutical Education Network Meeting, Ann Arbor, November, 2002.

"Development of Oral Formulations of a Novel Cytokine", Derrick S. Katayama, Lorelie Villarete, Danny Chou, Rajiv Nayar, and Mark C. Manning, Global Pharmaceutical Education Network Meeting, Ann Arbor, MI, November, 2002.

*G. Patent Applications:*

Work done as a faculty member:

"Ion-Pairing of Drugs for Improved Efficacy and Delivery", Eli Shefter and Mark C. Manning, patent application 07/961,162 filed October 14, 1992. PCT Int. Pat. Appl. WO 94 08577. Abandoned and incorporated into applications listed below.

"Method for Producing Ultrafine Pharmaceutical Powders Using a Compressed Gas Antisolvent", Theodore W. Randolph, Mark C. Manning, Eli Shefter and Richard F. Falk, patent disclosure filed with the University of Colorado in September, 1994. Combined with the application above as "Solubilization of Hydrophilic Pharmaceutical Substances in an Organic Solvent and Preparation of Pharmaceutical Powders Using the Same". The United States patent application was filed on June 7, 1995 and foreign applications were filed as well. The US patent (5,770,559) was issued on June 23, 1998. A second US patent (5,981,474) was issued on November 9, 1999.

"Controlled Release Drug Delivery System for the Treatment of Inner Ear Disorders", Michael J. Hart, Mark C. Manning, R. Michael Kelly, Jeffrey D. Meyer, James Matsuura, and Eli Shefter, patent disclosure filed with the University of Colorado in May, 1995. The University decided to pursue a patent application as of August, 1995. A provisional patent application. No. 60015572, was filed with the United States Patent and Trademark Office on April 18, 1996. Full U.S. and PCT patent applications (WO9738698A1) were filed on April 18, 1997 listing Eli Shefter, Mark C. Manning, and Michael Hart as inventors.

"Temperature Sensitive Gels for Sustained Delivery of Protein Drugs", Lewis P. Stratton, John F. Carpenter, and Mark C. Manning, patent disclosure filed with the University of Colorado in September, 1995. A United States patent application, number 08/679,199 was filed on July 12, 1996. A US patent (5,861,174) was issued on January 19, 1999. A

divisional application was filed was filed on January 15, 1999. A European patent application (EP910342A1) was filed on March 15, 1999.

"Biocompatible Cationic Detergents and Uses Therefor", Eli Shefter, James A. Ruth, Jeffrey D. Meyer, Mark C. Manning, David J. Kroll, and David J. Claffey, patent disclosure filed with the University of Colorado in January, 1996. A provisional United States patent application was filed on September 13, 1996. Full U.S. and PCT patent applications (WO9810649A1) were filed on October 29, 1996.

"Biodegradable Antibiotic Beads for Treatment of Osteomyelitis", Mark C. Manning, Theodore W. Randolph, Richard F. Falk III, Jeffrey D. Meyer, Stephen J. Withrow, and William J. Dernell, patent disclosure filed with the University of Colorado, January, 1996.

"Improved Formulations of Oral Antibiotics for Administration to Animals and Humans", Mark C. Manning, Jeffrey D. Meyer, Richard F. Falk III, Theodore W. Randolph, James E. Matsuura, Eli Shefter, and Ryan R. Manning, patent disclosure filed with the University of Colorado, January, 1996.

*NOTE: An exclusive license for all of the above intellectual property was assigned to RxKinetix, Inc. by the University of Colorado, March, 1997.*

"Sustained Release Composition Including Amorphous Polymer", Theodore W. Randolph, Richard Falk, and Mark Manning, patent disclosure 8045 filed with the University of Colorado, November, 1997. A provisional U.S. patent, 60/078,390, entitled, "Sustained-Release Composition Including Amorphous Polymer", was filed in March, 1998. A PCT application (WO9947543A2) was filed in March, 1999. A US patent application (09/403,412) was filed on March 8, 2000. A continuation was filed on June 7, 2001.

"Controlled Release of Ribozymes from Biodegradable Microspheres", Mark C. Manning, Theodore W. Randolph, Robert Beauvais, Richard Falk, and Mark Reynolds, patent disclosure filed with the University of Colorado, November, 1997. The intellectual property was assigned to Ribozyme Pharmaceuticals, Inc., Boulder, CO in March, 1998.

"Metal-Assisted Hydrophobic Ion Pairing", Jeffrey D. Meyer and Mark C. Manning, patent disclosure filed with the University of Colorado, April, 1998.

"Controlled Release of Anticancer Drugs from a Thermosensitive Gel", Mark C. Manning, William S. Dernell, Victoria Breghazzi, and Stephen J. Withrow, patent disclosure filed with the University of Colorado, September, 1998. A provisional patent was filed in November, 1999.

"Hydrophobic Ion Paired Drug Complexes for Controlled Release and Tunable Potency", Douglas Pitera, Corinne Lengsfeld, Mark Manning, and Ted Randolph, patent disclosure filed with the University of Colorado, October, 1999. A provisional patent was filed in November, 1999.

"Novel Drug Delivery System for Treatment of Local Infections", Mark C. Manning, Derrick Katayama, Douglas Pitera, Corinne Lengsfeld, and Theodore W. Randolph, patent disclosure filed with the University of Colorado, April, 2000. A provisional patent was filed in September, 2000.

"Increased Potency of Antibiotics and Anticancer Compounds via Ion Pairing" Mark C. Manning, William S. Dernell, Theodore W. Randolph, Lixin Feng, Danielle S. Biggs, and Derrick Katayama, patent disclosure filed with the University of Colorado, May, 2000. A US patent application (09/717,486) was filed on November 20, 2000, entitled "Compositions and Methods for Administering Chemotherapeutic Agents".

"Stabilization of Nebulized Solutions of Tissue Plasminogen Activator", Derrick Katayama, Mark C. Manning, John Repine, and Kathleen S. Stringer, patent disclosure filed, September, 2002. A provisional patent application is to be filed in October, 2002.